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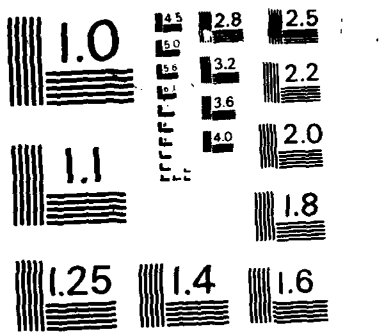

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FINAL REPORT

ERDYM: Economic Recovery Dynamics Model

Volume I: Modifications and Simulations

May 1984

Approved for Public Release:
Distribution Unlimited

Prepared for
Federal Emergency Management Agency
Washington, D.C. 20472
under Contract No. EMW-C-0909
Work Unit 4342-D

Battelle
Pacific Northwest Laboratories

LEGAL NOTICE

FINAL REPORT

ERDYM: ECONOMIC RECOVERY DYNAMICS MODEL

VOLUME I: MODIFICATIONS AND SIMULATIONS

by D. B. Belzer
J. M. Roop

May 1984

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Prepared for
Federal Emergency Management Agency
Washington, D.C. 20472
under Contract No. EMW-C-0909
Program Manager: G. J. Rosenkrantz
Work Unit 4342-D

Battelle
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The economic recovery of the U.S. economy after a major disaster is the focus of a systems dynamics model described in this report. The work under this contract involved restructuring the investment sector, constructing and embedding a monetary sector into the model, rebasing the model to 1972 data, some simplification of the structure of the model, the development of substantial software that eased the task of running and reporting the results of the model, and a number of other changes. Results are reported for historical simulation of the

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20. model and for a variety of simulations under alternative assumptions about destruction resulting from a nuclear attack.

ABSTRACT

The economic recovery of the U.S. economy after a major disaster is the focus of a systems dynamics model described in this report. The work under this contract involved restructuring the investment sector, constructing and embedding a monetary sector into the model, rebasing the model to 1972 data, some simplification of the structure of the model, the development of substantial software that eased the task of running and reporting the results of the model, and a number of other changes. Results are reported for historical simulation of the model and for a variety of simulations under alternative assumptions about destruction resulting from a nuclear attack.

ACKNOWLEDGEMENTS

We would like to extend a special word of thanks to the technical contract monitor for this project, Gerald Rosenkrantz. His support was appreciated throughout the project, and especially during 1983 when an overloaded FEMA computer system hampered progress toward completing the project. He also provided some special insights into the behavior of the monetary sector that aided the conceptualization phase of the study. We also appreciated the opportunity to interact with other interested FEMA staff, especially George Devine, Robert Wilson, Ted Su, and Lawrence Salkin. Bill Morrison, in FEMA's computer support group, was very helpful in maintaining and modifying the DYNAMO software used for the project.

SUMMARY

BACKGROUND

This research was undertaken to improve an Economic Recovery Dynamics Model (ERDYM) previously developed for FEMA (Peterson 1980). It is designed to examine policies that might affect recovery in a post-attack environment. The major modifications in this version of ERDYM are the following: the introduction of a monetary sector to the model that endogenizes interest rates; the restructuring of the investment sector to more closely follow economic theory; and the rebasing of the model to 1972 data. In addition, the model was simplified and other sectors were altered as needed to make the model consistent. Major software enhancements were also undertaken to make using the model and interpreting the results easier.

FINDINGS

The improvements made to the model alter its dynamic behavior substantially. Historical simulations over the period 1972-1983 reveal that the model tracks real gross national product to within 5 percent of actual. Comparison of other economic variables shows that the model exhibits growth characteristics that are suitable for an economic recovery model. In simulations of post-attack recovery, the model appears more robust to high levels of destruction than the previous version. This finding is likely attributable to the change in the investment sector of the model. Monetary policy simulations show that monetary policy alone has little effect on the real trajectory of recovery, although it can have substantial effect on price levels. In simulations where the level of destruction is uneven across sectors, the model suggests that targeted measures, such as direct consumer rationing, would be more effective in spurring recovery than general monetary and fiscal policy. An examination of post-attack simulations indicates that there are nonlinearities in the effect on the economy of different levels of destruction--destroying 30 percent of assets and population has more than three times the effect that only destroying 10 percent would have. These nonlinearites are closely linked to the way that psychological impacts are handled in the model. A decomposition of these psychological imacts shows that

nonlinearities disappear when the effect of these psychological factors is removed.

EVALUATION AND IMPACT

The systems dynamic model modified in this report is capable of simulating an attack of varying orders of magnitude while applying a number of alternative policies to influence recovery. The improvements have made the structure of the model more consonant with economic theory, insofar as they have been restructured. But some serious problems remain. Specifically, three areas are of major concern: consumption, the labor sector, and foreign trade. Consumption in some cases, for example, is not currently based on relative prices, but rather on assumed priorities; this gives rise to unreasonable consumer behavior in the face of sharp changes in relative prices.

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1.0 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

In the summer of 1982, the Federal Emergency Management Agency (FEMA) requested proposals to modify and improve the Economic Recovery Dynamics Model (ERDYM) developed under a previous contract (Peterson 1980). Battelle, Pacific Northwest Laboratories (BNW) received the contract to make the modifications to the model. This final report details and explains the major changes to the model, which include adding a financial sector, calibrating the model to 1972 National Income and Product Accounts, and modifying other sectors of the model to assure that the historical simulations were within a specified degree of accuracy. Once these changes were completed, the model was to be simulated for several major attack scenarios and the results of these simulations reported.

This chapter will provide some background as to why certain alterations and additions were made to the model, and will provide an outline of the report. The remainder of the report will document the changes and results of the reconstructed economic recovery dynamics model.

The second chapter of this report will provide an overview of the original model. It will briefly describe the various sectors of the model and several of the its equations.

The subsequent two chapters elaborate on changes made to the model in this study. Chapter 3 first describes the theoretical arguments underlying the restructuring of the investment sector. Consonant with these changes, a supporting monetary sector was developed and is also described in this chapter. Chapter 4 then describes changes in other sectors of the model that were necessitated by changes elsewhere, were done to simplify the structure of the model, or were required to calibrate the model to historical data. In a dynamic model such as ERDYM, the initialization of the model is critical to its near-term performance. Accordingly, considerable effort was devoted to the initialization of the model.

Chapter 5 presents a baseline initialization, historical simulations, and tests the sensitivity of the model to several characterizations of monetary policy. The historical simulations highlight the ability of the model, under a certain set of parametric assumptions, to replicate the dynamic path of the economy from 1972 to 1984. These historical simulations track the growth path of the economy within acceptable error bounds and also generate realistic cyclical behavior.

Chapter 6 then reports the recovery scenarios that were simulated for this project. In simulating the model under different assumptions about intensity of attack and alternative policy prescriptions, a great deal was learned about the dynamic structure of the model. In particular, we find that the model is quite sensitive to alternative assumptions about policy rules, capital-labor substitution and psychological effects. Modest changes to these assumptions can have dramatic effect on the recovery path of the economy, as described by the model. These results lead us to conclusions that are reported in Chapter 7 of this report. Recommendations for further changes to the model are then suggested in the final chapter.

Two appendices accompany this report. The first is a technical description of the development of the industry data used to initialize the model to its new 1972 base. The second appendix is a set of instructions to potential users, describing how the government policy levers within the model can be simulated. A separate user's guide repeats this information as well as provides complete instructions on how to use the model and prepare various types of reports.

1.2 BACKGROUND

FEMA's decision to modify the economic recovery dynamics model was made, in part, because of shortcomings in the performance of the previous version of this model. Another reason for this action was the criticism that the economic structure of the model received on review by economists from other government agencies involved in the exercises undertaken by FEMA as part of their emergency management planning. Specifically, the criticisms included the following: that the assumption that interest rates were not determined within the model was unrealistic; that the model lacked the basic national income and product accounting of a macroeconomic model; and that sectors of the model were specified in ways inconsistent with economic theory and empirical evidence. A more severe problem arose in simulation exercises with the model: when interest rates rose above certain modest levels, the model responded by spiraling down to a non-recoverable level of economic activity without even the advent of a disaster.

Battelle's review of the model recognized that system dynamics was an appropriate approach to modeling post-attack economic recovery and that the previous model was an ambitious attempt to model the economy. However, the model was criticized on a number of points. The model appeared overly complex as a representation of the economy in post-attack recovery. Since the basic choice set appeared to be between present and future consumption, it appeared to Battelle that the model could be somewhat simplified yet retain this basic focus. A more severe charge leveled at the previous version criticized it for its peculiar representation of some economic decision making. One example of this peculiar structure could explain why the model spiraled into depression.

The particular example used in the proposal was the characterization of business financial decisions. The model structured the availability of business finance as a major constraint on expansion of capacity. In other words, desired capital purchases could not be undertaken when a sector's financial position was inadequate to support investment. The capital budgeting approach used in the model to explain investment was, in consequence, very sensitive to interest rate fluctuations. The mechanism might work as follows: as interest rates rose, debt servicing increased. This put additional financial requirements on the sector, which required additional borrowing; this cut further into retained earnings, or required further reductions in capital spending. All these factors worked in the same direction--to lower investment, to make it more difficult to borrow, and to reduce the availability of internal funds to finance capital accumulation. With all these forces operating in the same direction, it did not take long before the sector was forced into a position that it could not pull itself out of. Thus the downward spiral.

In light of this criticism, Battelle's proposal focused on restructuring the business investment decision process and linking this revised investment model to a newly developed financial sector. The financial sector would determine an interest rate that would enter as an argument into the rental cost of capital. The feedback mechanism would be provided by business financial flows from the business sectors to the monetary sector. These financial flows, in turn, would influence the behavior of the monetary authorities. If structured reasonably well, the feedback loops from interest rates to investment to business flows to interest rates would be self-correcting. The proposal was predicated on the idea that these two major changes to the model, along with the addition of national income and product accounts and some simplification of the model, would serve to set it right.

Subsequent events suggest that this idea was somewhat naive. In anticipation of the conclusions of this study, Battelle has found that there are other major shortcomings to even the revised model. The strategy of this project has been to modify that which can easily be changed, but to circumvent other problems that exist as a result of misspecification of other sectors of the model. Because these major problems still remain, ERDYM must be used with caution. Areas that require this special caution are highlighted throughout the remainder of this report so that users of the model will avoid some pitfalls that our efforts have uncovered. The recommendations chapter that concludes this report details the remaining problem areas and suggests remedies.

2.0 MODEL OVERVIEW

This chapter provides an overview of the structure of Economic Recovery Dynamics Model (ERDYM). The intent of the discussion here will be to provide the reader with sufficient information to understand the basic workings of the system and to put the work in the current study into proper perspective. Since this description of the model draws heavily on the Pugh-Roberts report (Peterson 1980), the reader who wishes a more detailed treatment is referred to that earlier report.

2.1 INPUT-OUTPUT STRUCTURE

ERDYM may be characterized as a dynamic input-output simulation model of the U.S. economy. The economy is divided into 14 productive sectors as shown in Table 2.1. These sectors can be divided into three functional areas: production, product transfer, and consumption. The producing sectors (metals, non-metals, energy products, non-fuel consumables, capital, construction, agriculture and consumer goods) are those whose output is primarily physical goods. These goods can be inventoried and can be later used by other sectors either as intermediate inputs to production or sold to final consumers. The product transfer sectors serve as intermediaries between producers and consumers. The transportation sector most vividly falls into this category, although medical services and trade and services can also be interpreted as fulfilling this sort of function. Households, government and exports are consuming sectors within the model.

A nuclear attack or other major disaster would damage different sectors to different degrees, creating imbalances in available factors of production and demands. The use of input-output structure can improve the realism of the analysis, thus it can aid the formation of policies that will alleviate potential imbalances and optimize recovery.

The input-output structure serves to interconnect the 11 production and product transfer sectors. The output of each sector may be used as an input within the sectors, may be shipped to the other sectors to be used as inputs to production, or may be sold to final consumers. The model conserves physical flows of products, these inventories are adjusted when factor demand outstrips total supply in the short run.

TABLE 2.1 Sectors in ERDYM

1. Metals
2. Non-metallic materials
3. Energy products
4. Non-fuel consumable materials
5. Capital equipment
6. Construction
7. Consumer goods
8. Agriculture
9. Medical services
10. Transportation
11. Trade and services
12. Government
13. Households
14. Exports

In this study, the model was calibrated to the appropriately aggregated version of the 1972 input-output table published by the U.S. Department of Commerce. The 12-sector (this calibration is discussed in more detail in Chapter 4) table was used to parameterize the model, providing initial conditions for intermediate input requirements and final demand components. During simulation, the model is capable of adjusting the input-output relationships on the basis of technological advancement or in response to input shortages.

2.2 FINANCIAL STRUCTURE

The financial structure of the model incorporates many aspects of corporate financial decision making, including capital investment, debt acquisition, dividends, and pricing. ERDYM maintains simplified versions of an income statement and balance sheet for each of the production sectors. The relative values of the financial variables, such as return on capital, debt and revenues, help to characterize the financial soundness of each sector, which in turn influences capital investment and production. The subsequent chapter will describe this linkage to investment decisions more thoroughly, as this area has been extensively respecified in the current study.

2.2.1 Income Statement

The income statement focuses on revenue and costs. Revenue is defined as unit sales (equivalent to amount of output used in the economy, not production) times price. To calculate price, a target profit margin is calculated and added to unit costs of production. To account for short run periods of excess demand or supply, a multiplicative factor is applied to the cost of production (plus target profit margin). This factor generally depends on how far the level of inventory stocks deviates from some desired level.

Costs are classified as either fixed or variable. Variable costs depend on the level of production activity; they include wages and benefits, costs of intermediate (materials) inputs, and transportation and marketing costs. Fixed costs include rent, interest on debt, property taxes, maintenance costs, and depreciation. In the short run, these items are independent of the sector's level of production.

Before-tax profits are basically total revenue minus total cost. Income tax is calculated as a simple fraction of before-tax profits in the current period. Dividends are based on a moving average of after-tax profits, using the geometric smoothing function of the DYNAMO language. Retained earnings are simply the difference between after-tax profits and dividends paid.

2.2.2 Balance Sheets

The balance sheet for each sector adheres to the standard accounting identity: Assets = Debt + Net equity. Each item in the balance sheet is a level variable in terms of DYNAMO. Double entry bookkeeping assures that the accounting identity is preserved in each period of the model. To assure that the identity holds in the base period of the model, an initialization equation computes equity as the difference between initial values of assets and debts.

Three assets are distinguished in the model: book value of capital, book values of inventory, and cash. Changes in the book value of capital respond to gross investment, depreciation, and the values of any capital loss. The book value of inventories depends upon the differences between variable cost of production and cost of goods sold. Cash, which covers a variety of short-term assets as well as demand deposits, is influenced by a number of variables: retained earnings, new debt borrowing rate (+), repayment of debt principal (-) and capital investment rate (-).

2.2.3 Debt

A sector may acquire new debt for working capital or for capital investment. When current cash is insufficient to meet current expenses, a sector may borrow for working capital. Borrowing for capital investment is a financial policy decision and is influenced by the need for additional capacity and by the interest cost of the new debt. Chapter 3 discusses in more detail the role of debt acquisition with regard to capital investment.

2.3 PRODUCTION FUNCTIONS

Production relationships within the ERDYM are specified according to what Pugh-Roberts (P-R) terms the "soft-minimum production function." The production function for each sector determines the maximum output that can be produced given available quantities of labor, capital, and intermediate inputs. The presence of a production function provides a supply side to the model and permits the modeling of rationing and allocation systems to handle cases of shortages of one or more factor inputs.

The production function in ERDYM is most clearly illustrated in the case of two inputs, although it can be generalized to any number of inputs. Figure 2.1 is reproduced from the 1980 P-R report and shows the basic form of the production function used. The first term on the right of the equal sign in the equation shows the amount of output that could be achieved from the available quantity of input B if all other inputs were available in normal quantities. If input A is not completely available, then only a fraction of the potential output from input B will be realized. This fraction is termed by P-R the "adequacy of input A."

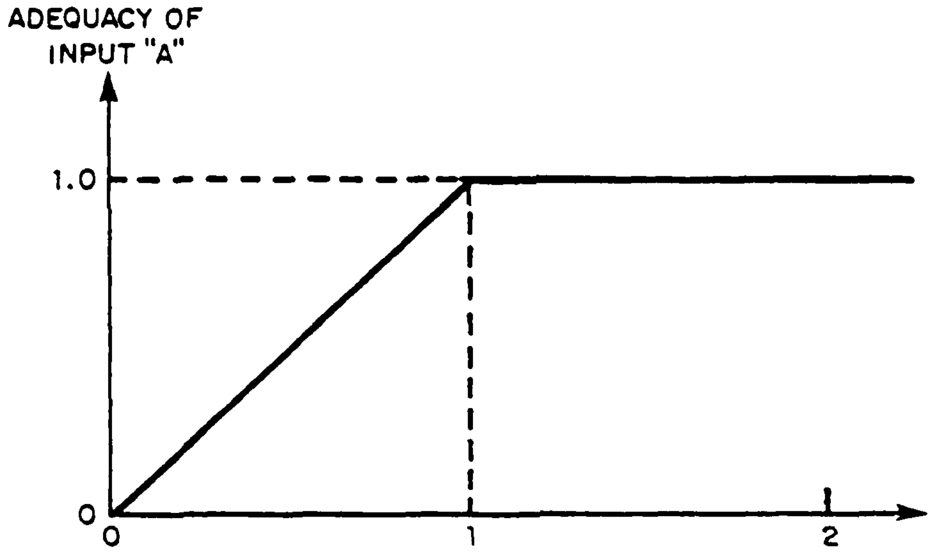
The determination of the adequacy of input A is the key to the production function used in the model. As P-R discusses this determination, "The adequacy is determined by the ratio of the potential output from the available quantity of A (assuming unlimited quantities of B), divided by the potential ouput from the available quantity of B (assuming unlimited quantities of A)." If this ratio is less than one, then input A is in relatively short supply, and becomes the limiting factor of production. If the ratio is greater than one, then B is in short supply.

The specification of the adequacy function (for A) may vary according to the importance of A and its rate of use in production. The adequacy function in Figure 2.1 corresponds to inputs that are critical to production, such as production workers and (embodied) materials. If there is a shortage of any one of these inputs, production may be limited or stopped altogether. Thus, the overall production function is the simple minimum of the potential outputs from the various factor inputs, each assuming an adequate supply of all others.

The strict proportionality relationship shown in Figure 2.1 may be inappropriate for some sectors. This may occur, as Pugh-Roberts posits, "...when the complete lack of some kinds of machinery may slow production but not stop it (as is the case when the operation may be performed more slowly with hand tools)." The top panel in Figure 2.2 shows the adequacy function in the case of a non-essential input to production. In this particular case, even when input A is unavailable, the value of the adequacy function is .5.

SECTOR OUTPUT = (POTENTIAL OUTPUT FROM INPUT "B") * (ADEQUACY OF INPUT "A"),

WHERE (ADEQUACY OF INPUT "A") IS DETERMINED BY:



$$\text{RATIO}: \frac{\text{POTENTIAL OUTPUT FROM INPUT "A"}}{\text{POTENTIAL OUTPUT FROM INPUT "B"}}$$

FIGURE 2.1 Production Function Employed in ERDYM (Peterson 1980)

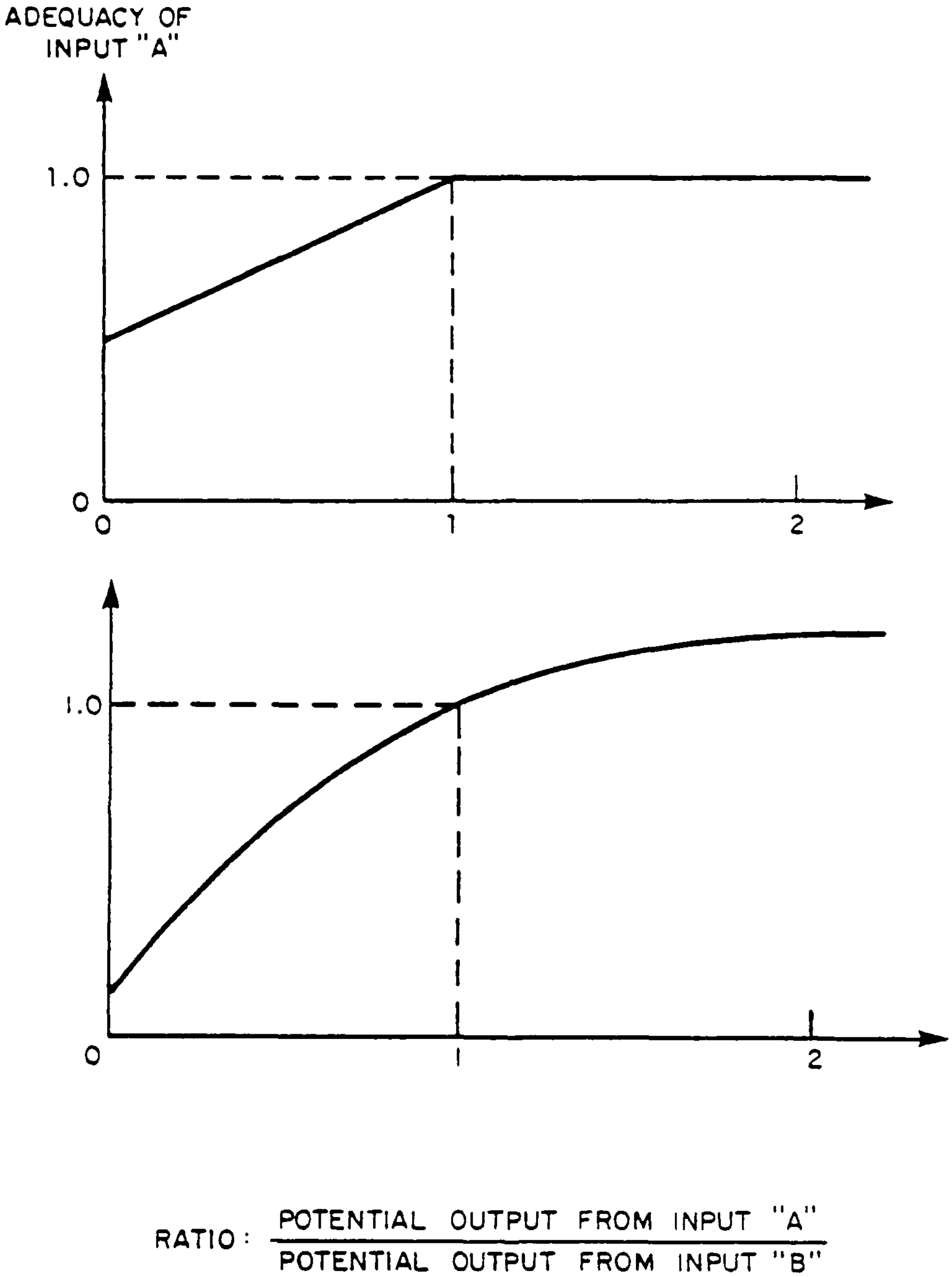


FIGURE 2.2 Variations of Production Functions in ERDYM (Peterson 1980)

This characteristic of the adequacy function is why Pugh-Roberts labeled this specification the "soft-minimum production function."

The prodution function used in ERDYM can also represent impacts with variable elasticities. Such a case is shown in the bottom panel of Figure 2.2. In this case a small reduction in input A is not expected to seriously impact production capability. However, the constraining impact becomes proportionately greater as the severity of the shortage is increased.

2.4 RESOURCE ALLOCATION

ERDYM contains a fairly elaborate allocation mechanism that can be used to simulate potential government rationing programs. This mechanism is based on the existence of variables that explictly account for demand, orders, planned production, inventory change, and import availability. In each period of production, the shortfall is computed for each sector. If the shortfall is zero, then all sectors (intermediate as well as final consumers) receive exactly what they order. If the shortfall is positive, each sector receives what it orders less a fraction of the overall shortfall. The specific values of the fractions depend on the relative proportion of total demand and on a set of pre-specified priority weights.

Under conditions of a production shortfall, ERDYM uses a function termed a SHARE macro to allocate supply. For two sectors competing for a single product, the mathematics of the SHARE macro is fairly straightforward. Equation 2.1 indicates the amount of product allocated to sector 1; Equation 2.2 does likewise for sector 2.

$$R1 = D1 - SF * (D1/PR1)/((D1/PR1) + (D2/PR2)) \qquad (2.1)$$

$$R2 = D2 - SF * (D2/PR2/((D1/PR1) + D2/PR2)) \qquad (2.2)$$

where

R1, R2 = production received in sectors 1 and 2, respectively

D1, D2 = demands for sectors 1 and 2, respectively

PR1, PR2 = priority weights for sectors 1 and 2, respectively

0 PR1 1, 0 PR2 1

SF = shortfall

The specification of Equations 2.1 and 2.2 ensures that:

1. total deliveries to all demanding sectors equal total supply
2. under normal market conditions, with adequate supply, each sector receives the quantity it orders (and no sector receives more than orders)
3. when shortages are present, uniquely low priority sectors absorb most of the shortfall.

A distinct advantage of the allocation mechanism in ERDYM is that it can provide a smooth transition from a normal market economy to one in which severe shortages are present. Various specifications for priorities may be tested in order to analyze the role of government allocation policies promoting recovery.

2.5 HOUSEHOLD SECTOR

The U.S. population in ERDYM is broken out into age, employment, and health classes. This disaggregation helps to determine both the composition of consumption expenditures and labor supply. In general, consumer demand depends on the subsistence needs of population and on the most recently achieved real standard of living. Labor supply depends on the availability of consumer goods over and above subsistence levels and on the psychological state of the population.

2.5.1 Consumption

The consumption portion of ERDYM determines consumer demand for nine major categories: food, energy, automobiles, other consumer durables, non-fuel consumables, transportation, personal services, housing, and medical care. The specification of demand is fairly simple. Since consumers generally expect an ever-increasing standard of living, the demand for most commodities is modeled on the basis of growth factors determined from historical data. For subsistence categories, food and medical care, minimum levels per capita are set to establish survival-level floors.

The sum of total desired consumer expenditures is then compared to funds available for consumer expenditure. Available funds depend not only upon current household income but also upon prior savings and availability of consumer loans. When funds are insufficient to finance desired expenditures, SHARE macros (as discussed in the previous section) are used to finally allocate funds to the given budget constraint. Rationing can also be imposed by the government to modify the demands stemming from the system just described.

2.5.2 Labor Supply

The potential labor force in the model is comprised of persons aged 16 to 65; workers within this age group are either employed or unemployed. The demand for labor for each sector depends on planned production. Adjustment to desired labor demand by firms is not instantaneous, as there are hiring delays. The model also takes account of labor hoarding during recessionary periods: workers are laid off only after appropriate delays.

The unemployed population is broken out into two groups: those within the labor force and seeking employment, and those not in the labor force. The movement of people in and out of the labor force depends on the health condition of the population, public confidence, and the perceived duration of unemployment.

The health condition of the potential labor force is a critical factor to economic recovery after on attack. The health condition is represented in the model by specification of a "sick" or injured population. The size of this group depends upon the adequacy of medical care facilities. Individuals recovering from injury enter a group of workers termed by Pugh-Roberts as the "well labor - not in labor force pool." Here public confidence is a key variable in deciding how quickly these workers will actually enter the active labor force. Factors that determine the state of public confidence are discussed below.

2.5.3 Psychological Factors

ERDYM contains an elaborate psychological effects sector that distinguishes it from a conventional economic model. This sector seeks to model the attitudes and sentiments of the population that in turn impact upon their economic behavior.

The key psychological variable in the model is an index of public confidence. This factor is a measure of that degree to which the population believes that productive effort and saving will produce long-run benefits. Three specific economic variables are affected by the public confidence index. First, the savings rate is higher for higher levels of public confidence as people (again) develop confidence in the financial institutions in the economy and believe future benefits outweigh the sacrifices in current consumption. The savings rate will be lower if people are experiencing subsistence levels of income or if they perceive that the probability of receiving future benefits from current saving is low.

Second, the productivity of the employed labor force is affected by the state of public confidence. High morale among the population, historically evident during wartime periods, is expected to enhance labor productivity.

Third, the rate of labor force participation depends upon public confidence. If public confidence declines to very low levels, it is expected that workers may withdraw from organized productive activity as concerns for the immediate subsistence of family and friends become more paramount. These concerns may be manifested in looting or subsistence activities, which would contribute little to GNP. The index of public confidence is, in turn, influenced by economic variables, as shown in Figure 2.3 reproduced from the 1980 Pugh-Roberts report. The three economic variables are the level of GNP per capita, its perceived rate of change, and the adequacy of resources for survival. A high level of per capita GNP compared to the traditional value (represented in the model as roughly a smoothed average over 10 years) will tend to improve public confidence. Even at low levels of GNP per capita, it is expected that improvements in standards of living will raise public confidence. Thus, both the direction and magnitude of change of GNP/capita affect the confidence index. Survival itself is tenuous in the aftermath of massive nuclear attacks; the measure of public confidence also depends upon the availability of subsistence food resources and the death rate of the population.

One of the psychological factors influencing public confidence is assumed to be lingering trauma from the widespread death and destruction that would be caused by a nuclear attack. Confidence will not improve until people recover

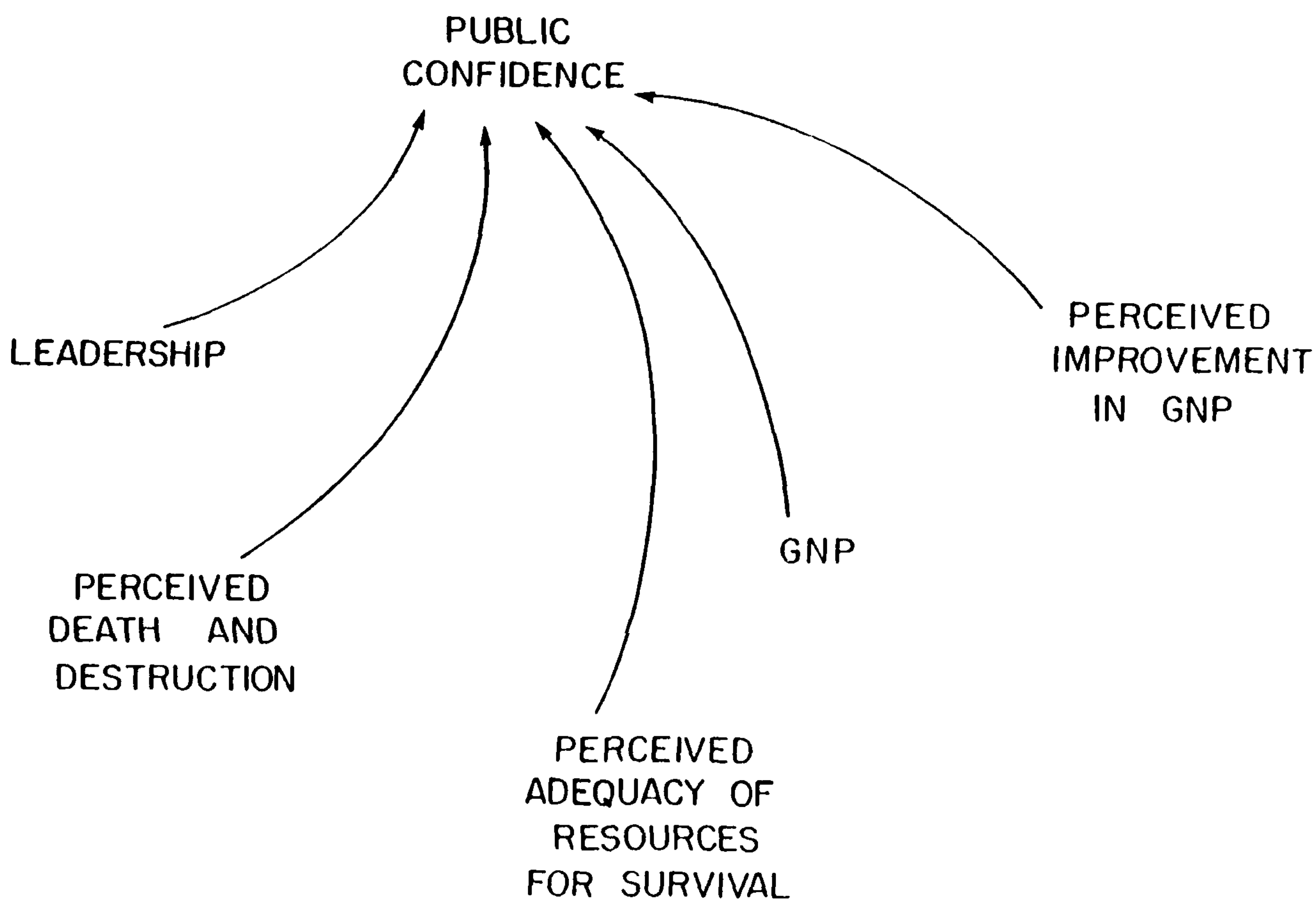


FIGURE 2.3 Factors Affecting Public Confidence (Peterson 1980)

from the shock of the deaths of family members and friends and either clear away the rubble of detroyed buildings or adapt to it.

Charismatic official leaders can also help to improve the morale of the population. This is assumed to only occur if the government had previously established a reservoir of goodwill by the strong leadership of political leaders or from efforts to prepare the population psychologically for an attack. In the model, the size of the reservoir is modeled as a stock variable, whose pre-attack value becomes a policy input.

2.6 GOVERNMENT

The government sector in ERDYM includes local, state, and federal activities. The government has two major functions. The first is economic; in providing public goods, the government collects taxes and purchases output from other sectors (including labor services). The government also redistributes income in the form of various transfer programs. The second major function is to regulate various aspects of economic behavior. In ERDYM key regulatory programs are rationing and wage and price controls.

2.6.1 Economic Role of Government

Revenues

The representation of government financing in ERDYM is straightfoward. Government revenues are comprised of the personal income tax, corporate income tax, state and local taxes (including federal excise taxes), and social security taxes. Each tax item is simply the product of an exogenous effective tax rate times the appropriate tax base. For estate and local taxes, consisting primarily of property taxes, the tax base is the total capital stock in each sector. For the other tax items, the tax base is the appropriate income item.

Expenditures

Government expenditures include purchase of goods and services, employee compensation, transfer payments, government subsidies to industry, and interest on the national debt. The demand for goods and services by government is represented by a function of the number of government employees. Government labor, in turn, is related simply to the total population by means of an exogenously specified multiplicative factor. Pugh-Roberts developed a means by which a military mobilization could be modeled within ERDYM. Mobilization increases demands in two ways. First, the increase in government employment caused by a mobilization pushes up demand for all goods and services. Second, the per-employee demand can be increased over and above its normal ratio, reflecting the extra demand that would be placed on key sectors. From work in the current study, transfer payments are now exogenously specified in terms of real (constant 1972) dollars per beneficiary. ERDYM inflates these values to current dollars based on the model-generated prevailing price level. Section A.5 in Appendix A provides a more detailed discussion of the breakdown of government transfers within the model.

Interest on the national debt is simply the product of an average government interest rate and the value of the debt. The average interest rate is continually updated and varies with regard to the magnitude of the additions to the existing debt and how much the current interest rate differs from last period's average. Current government deficit or surplus is simply the difference between total revenues and expenditures.

2.6.2 The Regulatory and Planning Role of Government

A number of potential government actions that can be implemented during a recovery scenario are built into ERDYM . Five basic sets of "policy levers" are available to allow simulation of possible approach of government intervention: production planning, rationing, wage and price controls, financial incentives and subsidies, and monetary policy. The discussion below describes the first four of these categories; monetary policy is discussed in detail in Section 3.3. Appendix B provides summaries of all the available policy levers and cites specific model variables and parameters that must be changed to simulate desired policy actions.

Production Planning

Within ERDYM government can influence the distribution of commodities by determining each sector's priority for obtaining those commodities in short supply. As Section 2.4 described, the resource allocation logic used in the model attaches a priority weight to the request of each sector for the output of another. By varying relative priorities, the model user can then test the sensitivity of recovery growth rates to various allocation schemes. This feature allows rapid analysis of a wide variety of central planning strategies, since the model is capable of simulating any combination of priorities.

Rationing

Direct rationing is a second means by which the government can alter the distribution of goods and services within the economy. Rationing within ERDYM is directed solely at the household sector. Resources freed up from limitation of consumer goods can then be directed toward investment activities that can expedite the recovery process. In ERDYM, rationing can be set on all consumer good categories, with the exception of housing and medical services. The model requires the time at which rationing is to start, the length of the rationing program, and the per-capita or per-household demand for each good during the rationing program.

Wage and Price Controls

Government can influence both the overall inflation rate and the pattern of relative prices by means of wage and price controls. Wage controls in ERDYM are represented by a constant upper limit on the annual percentage change in wages, applicable to all sectors equally. This representation is similar to the wage controls imposed during 1971 and 1972. Price controls are represented by a single variable that reflects the extent of market pressure (supply-demand balance) on sector pricing decisions. In periods of unbalanced inflationary pressures, this variable will have the effect of altering relative prices as well as moderating the overall rate of inflation.

Financial Incentives and Subsidies

ERDYM contains several means by which the government can influence economic decisions through financial incentives. For the most part, these cover incentives to stimulate investment activity. Specific incentives in the category include the investment tax credits, deferment of interest payments on debt, and accelerated depreciation. Direct subsidies are also a means by which an industry sector can obtain financing to stimulate investment activity. Subsidies are represented by adding (non-taxable) cash to a sector's revenues, which then can augment funds available for capital investment.

3.0 MAJOR STRUCTURAL CHANGES TO THE MODEL

3.1 INTRODUCTION

There are two major sectors that have been added or substantially revised in this version of ERDYM. First, investment decisions in the business sector have been modified to follow a neoclassical approach. The second major structural change to ERDYM is the addition of a monetary sector structured so that interest rates adjust to changing financial stocks and flows. The interest rates that adjust in the financial sector then feed back to both the business and consumption sectors to influence the financial flows that are accounted for in the monetary sector.

The investment sector embedded in ERDYM has been described in some detail in previous interim reports. The introduction of a monetary sector has necessitated some minor changes to the previous specification--specifically, the sensitivity of both business borrowing and business investment to interest rate changes has been modified. But with these changes, the investment sector still remains a neoclassical model of optimum capital accumulation rather than the investment sector originally defined in ERDYM, more accurately described as a capital budgeting model of investment.

The monetary sector introduced into ERDYM is built along lines suggested by James Tobin (1980). It is a general equilibrium model that recognizes the balance sheet and portfolio constraints that affect the behavior of the principal actors represented in ERDYM--households, businesses, financial institutions, and government. The balance sheet constraints apply across sectors--e.g., the new loan assets created by banks when they float business loans are exactly offset by the liabilities of the businesses--while the portfolio constraints apply to each sector. The introduction of a separate monetary sector allows for the determination of interest rates and more realistic behavior of the various agents within an economic model. It required the inclusion of a financial sector separate from those sectors previously identified in the model.

The introduction of a monetary sector into the model alters the behavior of economic agents in all sectors of ERDYM. Consider the behavior of four economic groups and how they interact. Consumers, whose income flows give rise to transactions demands, purchase goods and services paid for with money. Deferring current for future consumption, which results in the accumulation of wealth, is another choice of this group and can result in greater future income flows. The financial sector is a second group, and includes two further economic agents--banks and monetary authorities. The liabilities of the banks arise as consumers and businesses deposit funds to their institutions; these liabilities are offset with assets in the form of business and consumer loans and the purchase of government bonds. The monetary authorities pursue stabilization policies in response to changes in economic conditions. Businesses, a third group, can borrow directly from financial institutions thus creating loans--assets of the financial sector. The final economic group, whose activity is of only minor importance to this description of the interaction of major economic participants, is government. The fiscal policies of federal, state and local governments can have a direct effect on the behavior of the other participants only through their indirect effect on the balance sheet of the economy. This can occur when large discrepancies arise between revenue and expenditures (deficits or surplus) or when fiscal parameters that influence behavior, such as tax rates, are changed.

To modify ERDYM to reflect these behaviors, a number of structural changes have been undertaken. These structural changes are described in the remaining three sections of this chapter. In the next two sections, the investment and the monetary sectors are handled respectively. Each of these sections is divided into two parts. The first provides a theoretical framework for the subsequent implementation into ERDYM; the second describes the implementation of the theory in the model. The final section of this chapter will describe the policy pursued by monetary and fiscal authority, and the variables available to the user of the model. A more detailed discussion of the use of these policy variables is contained in Appendix B.

3.2 INVESTMENT

Since the accelerator model of investment was promulgated by Paul Samuelson in 1939, a variety of theories to explain investment behavior have appeared in the economic literature. Section 3.2.1 briefly describes some of these theories and discusses the empirical evidence to support them. From this set we select the theoretical structure most supported by the evidence. Section 3.2.2 then describes how the chosen theoretical structure is implemented in the model.

3.2.1 Alternative Theories of Investment

The theories of investment and their empirical implementation during the past thirty years can be conveniently summarized by the following five classifications. Many of the existing investment functions combine one or more of these theories, as does the system dynamics model we propose, but for purposes of exposition we can treat these strands separately.

Generalized accelerator. This most venerable formulation of the investment function has roots going back to the beginning of business cycle analysis (Tinbergen 1938; Samuelson 1939). The model was developed as a general distributed lag relationship involving both changes in, and level of, output, but the adjustment in any given period is only partial.

Cash flow model. In this version, current and past profits are thought to be a good proxy for expected future profits, which in turn determine investment. Other variants of this model have emphasized that cash flow is important, for it serves as a source of funds in the presence of risk and imperfect capital markets. In yet other variants, the amount of debt relative to assets or equity serves as a barrier to investment beyond which the cost of capital rises sharply. While no one has recently developed a pure cash flow model, it serves as a central variable in a variety of studies, including that of Duesenberry (1958).

Securities value model. The basic theory underlying the securities value model has been developed by Brainard and Tobin (1968). They state that, "One of the basic theoretical propositions motivating the model is that the market valuation of equities, relative to the replacement cost of the physical assets they represent, is the major determinant of new investment. Investment is stimulated when capital is valued more highly in the market than it costs to produce it, and discouraged when its valuation is less than its replacement cost." (pp. 103-104). To the extent that low equity values and a high debt/equity ratio occur concomitantly, that ratio may also be included under the aegis of the securities value model. The Brainard-Tobin theory received some public support as evidenced by the fact that it was used in both 1977 and 1978 Economic Reports of the President to explain why the ratio of investment to GNP has remained unusually low during the current business cycle recovery. Subsequent data revisions have raised questions about this explanation.

Standard neoclassical model. In this theory, developed by Jorgensen and Associates (see, e.g., Jorgenson 1967), each firm is assumed to be making adjustments toward a desired stock of capital. In contrast with the accelerator model, however, this model assumes that desired capital stock depends not only on equilibrium output but on the ratio of the output price to the implicit rental price of the services of capital goods.

Under fixed production technology and competition, the price of capital goods must equal the present value of fixed rentals. Hence the desired capital stock is equal to $a(\frac{px}{c})$, where p and x are the price and quantity indices of output, c is the rental price of the services of capital goods, and a is a constant equal to the responsiveness of output to capital. The rental cost of capital, c, is determined by a variety of factors including the price of investment goods, depreciation, rates of return, the discounted value of depreciation and of government programs such as tax rates.

Putty-clay neoclassical model. This theory, developed by Bischoff (1971a) takes as its point of departure the work of Jorgensen but permits the capital elasticities with respect to output and rental cost to differ. In addition, the rate of return is assumed to be a function of the long-term bond yield, the dividend/price ratio, and the expected rate of change of output prices. The model is known as "putty-clay" because factor proportions are assumed to be variable only up to the point that new capacity is put into place, after which they are "baked" into their final form. Hence rather than adjusting investment toward a desired level of capital stock, firms are assumed to adjust toward a desired level of productive capacity. As a result, they may react differently to changes in output and changes in the relative cost of capital.

Evidence of These Theories

The major comparisons of these various theories of investment have been undertaken by a variety of economists, most recently by Peter Clark (1979). The results are not unequivocal; in particular, Jorgensen and Siebert (1968) and Bischoff reach completely different conclusions about the worthiness of the standard neoclassical model. With this caveat, we report that the general conclusions are as follows:

1. Cash flow by itself--i.e., without considering the favorable effects of lower tax rates or more favorable depreciation--has no significant effect on investment. This means, for example, that a corporate cash rebate, or a lowering of the tax brackets for the first $100,000 of net corporate income, would have very little if any positive effect on investment. Indeed, Bischoff (1971b) reports that "The performance of the two cash flow equations, in contrast to that of the three models in which output plays a major role, is definitely inferior ... the results do not seem to support the profit-based model." (p. 33). Jorgensen and Siebert (p. 209) also conclude that "theories based on capacity utilization or profit expectations ... are superior to a theory based on internal funds available for investment." Hence at least this point appears to be well established in the literature.

2. The standard neoclassical model, which posits the same elasticity for output as for rental cost, is unduly restrictive and in general leads to poor forecasts and simulation results. The problem is clearly seen in a comparison given by Bischoff (1971b) for the predictive value of the five classes of investment functions mentioned previously for the period 1971-1973. Four of the five accurately predicted the sharp increase in real capital spending that occurred during this period; yet the standard neoclassical model predicted a slight decline. According to Bischoff, this failure is due to "the weakness of the accelerator effect in this equation, as well as the low long-run output multiplier." (pp. 42-43).

3. Taken together, the tax variables appear to have a potent effect on raising investment, although it is not clear whether this short-term effect continues in the long run. Work done by these economists shows

a close correlation between the change in investment and the lagged change in the effective corporate income tax rate--i.e., taking into account changes in all the tax laws affecting investment--once the effect of changes in output have been determined.

This evidence suggests that the most appropriate description of investment is one that takes into account real, discounted rates of return, output or capacity, and tax incentives on investment. Yet most of the system dynamics models of investment (e.g., Mass 1975; Day 1980) rely on the accelerator version of investment or on cash flow, as does the original version of ERDYM. In the next section we show how a model of investment can be structured to incorporate these additional considerations.

3.2.2 Implementing the Investment Sector

A major flaw in the specification of the previous version of ERDYM was the modeling of the business decision to invest. Whereas an economist would envision a firm making a rational decision to replace or expand the existing plant and equipment based on analysis of discounted returns and costs of the investment project, the model prior to modification structured that decision primarily as a financial one, largely placing the decision in the hands of lending institutions. Moreover, the financial institution's decision was based largely on the level of debt of the industry and the historical ratio of debt to equity. In the current version, these shortcomings have been corrected.

We have replaced the maximum debt-equity ratio that limited investment with a moving average of industry debt. This moving average then becomes the norm against which financial institutions measure their willingness to lend. But this willingness is modified by real interest rates along the lines suggested in the previous section. Thus the influence of the availability of funds on investment is tempered by the opportunity that investment provides to generate a return sufficient to cover its costs. So on the financial side we have altered the model to fit more realistically into the framework of the monetary sector described in the next section.

We have further modified the business sector at the point where the firm makes a decision to invest. The original version of the model added replacement and expansion demand for capital to determine desired capital purchases. As far as it goes, there is nothing wrong with the approach. We have expanded this decision-making apparatus to explicitly take into account the cost of capital. We have done so by constructing a user cost of capital variable that modified the desired level of capital purchases by reducing or magnifying desired capital as user costs are high or low, respectively. The user cost of capital is derived from the neoclassical theory of capital accumulation.

The neoclassical theory of capital accumulation, based on the work of Dale Jorgensen and others, argues that the relevant cost of capital that enters the business decision process includes a number of factors other than just the price of the capital goods. Specifically, the user should include the discounted tax value of depreciation; the tax rate applicable to the firm; other tax incentives such as the investment tax credit; appropriate measures of the finance costs associated with the capital undertaking, either through equity financing or borrowing; and the relative price of the capital goods compared to the price of the goods produced by that investment. We have constructed this user, or rental, cost of capital from the tax rates and interest rates that exist in the model.

The model uses this rental cost of capital measure to alter the levels of desired capital replacement or expansion. Once the rental cost variable is constructed, it is used as input to a function that acts as an investment multiplier--increasing the desired level of investment if the rental cost is low, reducing it if the rental cost is high. This multiplier, then, acts as an investment elasticity in a manner similar to the effects of interest rates discussed before.

The initializing data for ERDYM have been updated from 1965 to 1972. To change the initialization period, we have had to derive a number of series from published sources that need explanation. In the main, our strategy has been to use published sources of data where available, with only the necessary modification needed to fit within the framework of the model. The major intent of this section is to sketch out the sources of data and to describe the types of modifications made when the published data were inadequate.

There are several sources of data on which we have tried to rely. Where possible we have used the Bureau of Economic Analysis data in all the GNP accounting identities. Industry detail for employment, profits, and output are taken from the Bureau of the Census. We have used the 1972 Input-Output table to update the industry coefficients where applicable. Capital stock data are attributable to the Bureau of Industry Economics. All the agencies mentioned so far belong to the Department of Commerce. Financial data we have collected from the Federal Reserve System. But we have supplemented this financial data with industry detail available from the Internal Revenue Service--1972 Corporate Income Tax Returns.

We have relied on IRS data to develop an industry distribution of assets and liabilities. But these numbers have very little relationship to the published National Income and Product Account numbers. To align these different sources of data, we have relied on the Commerce data sources as benchmarks, using the IRS data to provide the appropriate industry distribution of balance sheet entries.

3.3 MONETARY SECTOR

The monetary sector that we envisaged introducing into ERDYM can be developed along lines suggested by James Tobin (1980). It is a general equilibrium model that recognizes the balance sheet and portfolio constraints that affect the behavior of major economic factors--households, businesses, financial institutions, government, and the rest of the world. The balance sheet constraint applies across sectors--e.g., the financial assets created by banks when they float business loans are exactly offset by the liabilities of the businesses--while the portfolio constraints apply to each sector. In the case of households, for example, the portfolio constraint assures that adjustment to assets held by the household sector in one time period are identical to net savings in that period. The structure of these relationships can be pictured as a matrix, with the sectors as headings for the columns and the rows identified for each class of asset. Then the balance sheet restrictions imply that entries for the different sectors on any row will sum to zero. Similarly, the portfolio restrictions require that the column entries sum to the change in the net wealth position of the sector; net savings for the household sector; the negative of investment to the business sector; the net surplus for the government sector; zero for the financial sector; and the current account deficit for the rest of the world. The balance sheet identity for this total row is the familiar savings-investment identity.

This matrix of financial flows is converted to a model of economic behavior when the entries in one or more of the cells of the matrix are treated as variables with equations explaining the acquisition or sale of the asset. Then the balance sheet constraints become equilibrating conditions for the asset market represented by the row, and the total rows for all sectors become the locus of the I-S curve. These flows occur within any single time period; a dynamic model can be constructed from these flows by having stocks adjust through time on the basis of these flows. Since this approach to stock adjustment is consistent with the system dynamics approach and DYNAMO, the Tobin general equilibrium approach seemed an ideal strategy to follow for modification of ERDYM.

As development proceeded on this type of model, it became evident that the structure of ERDYM could not support even a simplified version of a Tobin model--the financial flows simply did not exist. In consequence, the implementation of the model in a form suitable for ERDYM is less than the general equilibrium structure that was hoped for. The remainder of this section will detail both the theoretical structure of the model and the adjustments that were made to this structure to enable the construction of a financial sector in ERDYM.

3.3.1 Theoretical Structure

Begin by considering a financial system that consists of five sectors. These are households, businesses, financial institutions, government, and the rest of the world. The rows identify alternative assets. A matrix constructed to reflect this financial system is presented in Table 3.1. An entry in a cell of the matrix is the net transaction of the sector during the time period under consideration: refer to such an entry as ${}^{s}x_{i}$, where the x is the flow transaction, the s represents the sector, and the i identifies the asset.

Consider as an example, that the asset A1 is money. The entry under the household sector for this asset would be the net additions to demand deposits, increases in currency holdings, and possibly, additions to time and money market deposits, depending on the chosen definition of the money supply. The entry under businesses would be similar to the household sector; it would represent net additions (subtractions) to the cash account of businesses. Under the financial sector, the entry would represent the net increase in the liabilities of the banking sector that are included in the money supply, i.e., changes in demand deposits held by business and households. Since these are liabilities to the banks, this entry would have a negative sign. The government entry would represent net additions to high-powered money--currency and deposits that can be used as reserves. The final entry would be the foreign balance entry for the rest of the world that would represent the net capital flow on current account that falls within the definition of money. In the asset market for money, as for any other asset in a closed system, the sum of these five entries must be zero.

TABLE 3.1. Financial Flows Matrix

Assets	Households	Business	Financial	Government	Rest of World	Total
	Sectors					
A1	${}^{h}X_1$	${}^{b}X_1$				0
A2		${}^{b}X_2$				0
A3						0
Total	Net Savings	(-) Investment	0	Deficit	(-) Current Account Balance	0

The transactions that occur during the time period for a sector (the entries down a column) represent adjustment to the portfolio of the sector. Consider the household sector as an example. Within the time period used for analysis, the household will liquidate some assets, acquire other assets, alter its savings and demand deposits, and have assets revalued as a result of price changes during the period. The net change in the portfolio of the household sector will be the financial representation of the savings effected by that sector during the period.

This matrix of financial flows takes on the characteristics of an economic model when the entries in the cells become variables that are explained with behavioral equations. For example, the money holdings of households might be represented, in standard Keynesian terms, as a function of transactions demand, while other household asset demand might be more directly related to liquidity preference. Thus the savings function takes on the familiar form of most textbook representations--jointly determined by transactions demand and liquidity preference. As equations are added to explain cells in the matrix, the balance sheet identities become market clearing conditions; similarly, the portfolio identities allow the reduction of the number of markets considered. This form of financial model could be estimated econometrically exploiting the balance sheet and portfolio condition in the estimation of the parameters of the model.

But the approach taken here is quite different. The first step in the conversion of this theoretical framework to a financial model in ERDYM is the selection of the sectors and the identification of the flows in the model. The second stage is the development of the balance sheet identities that allow for a consistent monetary sector. The final stage, then, is the specification of monetary policy and how it influences the sector. These are the topics of the next section.

3.3.2 Implementation

Some thought had been given to the construction of a monetary sector in the original version of ERDYM. Two balance sheet items were identified in the model when work began on modification: the total loans and total demand deposits of the financial system. After updating the model to the 1972 data, these balance sheet flows bore little relationship to any reported financial statistics that the Federal Reserve published, so we began the work anew. The current specification of the sector balance sheet is given in Table 3.2.

The assets of the financial system consist of loans to the business sector and required reserves. The liabilities of the system are deposits from households and businesses, the reserve base, and borrowed reserves.

TABLE 3.2. Monetary Sector Balance Sheet

Assets	Liabilities
Total Loans	Household Demand Deposits Business Demand Deposits
Required Reserves	Monetary Base Borrowed Reserves

An accounting identity is maintained between the three reserve entries. As demand deposits grow, required reserves grow. These are satisfied by the growth of the reserve base, a monetary policy variable, or through borrowings. Changes in borrowed reserves affect the rate at which interest rates change. An approximate accounting identity is maintained between loans and changes in demand deposits. This is not strictly an identity because the financial markets for other assets do not currently exist in the model (more on this point later).

Business demand deposits are related to the change in business cash, one of the financial flows in the business sector. Household demand deposits are based on both the transactions demand for money and the interest sensitivity of holding money rather than earning assets that reflect lost opportunities. Specifically, the household money demand function is as follows:

$$HHDD_t = K_0 * Y_t * r^{-.2} \qquad (3.1)$$

Thus, the interest elasticity of the demand for money is -.2 and the income elasticity of the demand for money is 1. These numbers are reasonable approximations to the empirical evidence available.

Monetary policy impinges on the financial system in a number of ways. Required reserves are determined by the monetary authorities and established by fiat. Any additions to currency as a result of minting new money (net of replacement of retired currency) enter the financial system as high-powered money (reserve base). Open market operations, the third type of monetary policy, affect the financial sector through changes in the reserves available to meet reserve requirements. Sales and purchases on the open market will also alter the yields of government securities, thus changing the desired holding of these assets in the financial sector's portfolio of assets, as well as in other sectors' portfolio of assets. In the current representation of the monetary sector in ERDYM, this market adjustment occurs directly rather than through an equilibrating adjustment of portfolios in other sectors. Specifically, purchases of bonds by the monetary authorities results in a reduction of the reserve base, which forces the banks to borrow reserves to meet statutory reserve requirement ratios (assuming no reduction in deposits). Borrowing reserves affects the government interest rate, driving it up fractionally. Higher government interest rates in turn put upward pressure on the other interest rates within the economy, bringing about adjustments to the portfolio position of the banks.

To trace this effect, first consider the household demand for money. From the equation above, it is evident that a 10 percent increase in the government interest rate (or appropriate consumer rate) will reduce household demand deposits by 2 percent. This will reduce the reserve requirements for banks fractionally, thus reducing the need to borrow reserves. In short, the feedback mechanism is negative--it has a tendency, other things being equal, to correct itself.

In the business sector, the effects are less direct, but work similarly. Higher government rates, through the yield curve that links short and longer term rates, will bring about an increase in the business interest rate (historically the prime rate). This will tend to discourage business borrowing, discourage investment, and indirectly through changes in aggregate demand, reduce the sales of firms. At the same time, higher interest costs are factored in as higher production costs, and are translated into lower business cash positions--the key variable that determines business deposits. Thus, business demand deposits will also decline, indicating, again, a negative feedback loop.

We conclude this section with a brief discussion of the mechanism by which the change in reserve borrowing influences interest rates and how short-term rates are translated into a yield curve. Under normal policy conditions, the reserve base is adjusted to keep pace with required reserves under current deposit conditions, modified by a monetary policy function explained in more detail in the next section (the normal value of which is 1). The reserve base is then compared with the current status of reserves to determine if further reserves must be borrowed. The percentage of required reserves that needs to be borrowed is then interpreted as the rate at which the government rate changes, subject to maximum allowable fluctuations. The business interest rate follows the change in government rate, but with fractionally less amplitude of change. In similar fashion, mortgage and savings interest rates are likewise adjusted, but with respectively less amplitude of change. The consumer borrowing rate is presumed to remain fixed at its statutory maximum levels.

The implementation of monetary policy in ERDYM allows for a variety of policy rules, all of which can be modified to alter the simulation of the economy. The discussion of these policy options is the topic of the next section.

3.4 MONETARY AND FISCAL POLICY

As previously mentioned, the major focus of monetary policy is the reserve base out of which the banks can maintain required reserves. Under "normal" conditions, the monetary authorities, would allow the reserve base to grow at the same rate that required reserves grow, thus eliminating the need for banks to borrow reserve. But for conditions to be normal, three targets must be met. First the perceived rate of growth of GNP must be equal to the target rate of growth; second, the unemployment rate must be equal to its target rate; and third, the inflation rate must be equal to its target. The growth target policy variable, MPOL, is designed to magnify or reduce the growth of the reserve base as the growth trajectory of the economy is above or below the target. It acts in a multiplicative manner, just as the investment modifiers acted.

The unemployment-inflation tradeoff policy variable (UIPOL) also acts multiplicatively, but in quite a different manner. In this case, the policy variable is constructed with the explicit recognition that there is a tradeoff between these two goals (see Gramlich 1979). The design of the policy function is as follows:

$$UIPOL = w1*(UN/UN*)^{p1} + w2*(INF/INF*)^{p2} \qquad (3.2)$$

With deviations from an unemployment target (UN*) weighted by w1 and raised to a power (p1) in the same manner that deviations from an inflation target (INF*) are handled. In this case the weights must sum to one. All of the policy parameters of this function, the targets, the weights and the powers, are subject to manipulation by the person simulating the model. Furthermore, different regimes of policy--e.g., allowing higher inflation during recovery--are allowed.

Several other monetary policy options exist in this implementation of ERDYM. Interest rates can be exogenized throughout an entire simulation or only during recovery. An historical counterpart to the latter regime of policy was the monetary rule in effect after World War II that restricted interest rates to reduce the burden of wartime debt incurred. Alternatively, a monetarist rule--a constant rate of growth in base reserves--can be put into effect. A number of these options are shown as examples in the chapter detailing the simulations of the model.

The fiscal policy variables subject to control in this implementation of ERDYM are less rich in their effects, but do have some influence on the model. Industry corporate tax rates can be modified, for example, and this will influence the level of government revenues and have some bearing on the demand for capital equipment. If this policy lever is reduced, for example, it will reduce, at any given level of prices and interest rates, the rental cost of capital, thus stimulating investment. The same is true of modifications to the asset lives of equipment and to investment tax credits, and in changes to the depreciation rules with regard to equipment. But in this implementation of ERDYM, these effects are clearly less potent than they might actually be in practice.

4.0 OTHER MODEL CHANGES, REPORT CAPABILITY, AND MODEL INITIALIZATION

In addition, to the major changes in model specifications described in the previous section, work in the current study covered several other areas. First, a number of more limited changes were made to the structure of the model. Second, a significant effort was devoted to building an easy-to-use report generator for the model. Finally, in preparation for the historical simulations to be described in the next chapter, considerable attention was paid to model initialization. Each of these areas is described below in turn.

4.1 OTHER MODEL CHANGES

As the primary aim of this study was to respecify the investment and monetary sectors, changes in other sectors were generally performed to simplify the structure of the model or to help calibrate the model to historical data. Three main areas were addressed: 1) the rental building sector, 2) government transfer payment, 3) availability of imports.

4.1.1 Rental Buildings

The original Pugh-Roberts (P-R) model contains an elaborate rental buildings sector. Rental buildings were treated as if they could not be substituted for "owned" buildings. Thus, there were separate depreciation equations and allocation mechanisms specifically for rental buildings. This allowed the direct computation of rental payments as a component of fixed production costs.

In a long-run recovery model such as ERDYM, this treatment seemed both unrealistic and unnecessary. Rental payments are such an extremely small fraction of unit costs, that little impact would be expected if these payments were simply subsumed as part of the normal purchases from the trade and service sector (which includes the real estate sector). Allocation of rental buildings in a supply shortage is not really meaningful in the presence of owned buildings. Rental payments as a separate cost item were dropped from the model and were assumed to be reflected in the payments to the service sector. This change has the effect of simplifying the overall model structure and making the specification of the demand for buildings more transparent.

4.1.2 Transfer Payments

In the original P-R study, transfer payments were specified in terms of current dollars per year per beneficiary. This treatment yields different levels of household real income depending upon the specific price level generated by the model. Moreover, in the original specification, all transfer payments were divided into two categories--public assistance payments depending upon the unemployed population and social security payments.

In the present study all transfer payments are specified in terms of real (constant 1972) dollars per beneficiary. ERDYM inflates these values to current dollars based on the prevailing price level generated by the model. In addition, the public assistance category is now disaggregated to treat unemployment compensation and other transfer payments separately. The details of this revised treatment and data sources are discussed in Appendix A, section A.6.

4.1.3 Import Availability

The specification of import availability was changed in response to model behavior during recovery. In the original model the demand for imports and exports was influenced by an exogenous factor termed the "availability" of imports and exports. This time-dependent variable was introduced by P-R in order to limit foreign trade in the period immediately after a major attack. In normal conditions the value of thisvariable is one.

In some test simulations of recovery scenarios, total imports displayed a tendency to explode when the availability variable influencing exports and imports returned to its maximum (normal) value. If shortages persisted in the economy, total imports would sometimes exceed exports by as much as tenfold. The behavior is unreasonable in light of the fact that exchange rates would be expected to adjust over time to eliminate such imbalances.

To provide some sort of temporary remedy to this problem, availability variables were defined separately for both exports and imports. The export availability variable is specified exogenously, as before, and is time dependent. The import availability variable, however, is made a function of a variable called the balance of trade factor (BOTFAC). This variable is proportional to a smoothing function of the ratio of total exports to total imports. Thus, total imports are made to adjust in a reasonable fashion to the growth in total exports, although the procedure used does not maintain imports and exports strictly in balance. A more sophisticated approach would be to define a level variable for the exchange rate, which would continually adjust to eliminate any balance of trade deficit. Such a refined specification awaits further work on the model.

4.1.4 National Accounts Variables

The definition of familiar GNP components shown in the national accounts has been expanded considerably from the original model. For current dollar items, variables representing producers' durable and nonresidential structures are now defined in the model. In the original model, only GNP was available in terms of constant dollars. In the present study, variables for all of the major fixed investment categories plus personal consumption expenditures are now defined in both current and constant prices. These variables now allow the user to more quickly analyze the results of particular scenarios in terms of the major GNP aggregates.

4.2 REPORT CAPABILITIES

At an early point in the study, it became apparent that the existing print facilities provided by the DYNAMO complier were inadequate to allow the user to efficiently analyze the model behavior. Figure 4.1 shows an example of DYNAMO's standard tabular output. For a small model containing a few variables this format is sufficient. However, since only 14 variables can be printed on each line, a DYNAMO report for several hundred variables will necessarily take up many lines. As Figure 4.1 shows, all of the variable titles are printed en mass at the top of the report, followed by the scale factors, and then the actual variable values for each solution print interval.

To work with a complex model such as ERDYM, the analyst frequently requires that many variables be printed for the numerous "trace back" exercises required. Thus, in the initial work with ERDYM in this study, several

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TIME											
	RGNP	GNP	INFR	TPDE72							
	DEMDEP	RBASE	REQRES	MPOL	GIR	BINTR					
	AHSDEX	HSHDIN									
	P	2	3	4	5	6	7	8	9	10	11
	PRICE	2	3	4	5	6	7	8	9	10	11
	PDDP	2	3	4	5	6	7	8	9	10	11
E+00	E+09	E+09	E-03	E+06							
	E+09	E+09	E+09	E+00	E-03	E-03					
	E+00	E+00									
	E+06	E+06	E+09	E+09	E+09	E+09	E+09	E+09	E+09	E+06	E+09
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
	E+06	E+06	E+09	E+09	E+09	E+09	E+09	E+09	E+09	E+06	E+09
1972 0	1191 2	1191 7	59.650	77970.							
	177 10	24.60	24.79	.6517	44.00	55 00					
	10606	11344.									
	61230.	22650	109.36	177.93	237 44	160.11	84.42	197.26	55.15	76357.	729.9
	1.0318	.9686	.9606	1.0323	.9594	.9744	9689	.9669	1.0826	1.0590	9410
	61830.	23742.	110.63	183.74	250.31	164 87	92.12	200 96	56.96	76486.	752 8
1973 0	1224.3	1265.5	47.959	84348.							
	184 56	26.91	25 84	.7876	44.44	55 40					
	11133	12206.									
	63239.	23452.	112.08	187.38	262 52	162 47	88 26	198.50	55.21	77023.	759.3
	1.0762	.9997	.9697	1.0756	1.0528	1.0048	9874	9437	1 1360	1 0787	.9671
	64828.	23983.	113.64	187 95	259.96	162.47	88.65	200 18	60 06	77077.	764.8
1974.0	1252.1	1367.6	57.431	82477.							
	195.63	28.26	27.39	.8989	51.78	62.00					
	11938	13169									
	65787.	22086.	115.34	187.24	278 94	156 89	87 30	196 29	57 27	77317	782 3
	1.1508	1.0356	1.0287	1.1172	1.1755	1.0558	1.0141	.9561	1.1969	1.1307	1.0192
	67006.	23426.	117.40	189.32	262.25	156.89	89 24	199.90	63.03	77384	788 3

FIGURE 4.1. Example of DYNAMO Tabular Output

pages of variable names would be produced, followed by an equal number of scale factors, and finally, the solution values. With no convenient variable titles, it becomes a nearly impossible task to analyze the behavior of particular variables for simulations consisting of more than just a few time periods.

To remedy this situation one of the early tasks of this study was to construct an external report writer for ERDYM, which could be used in either batch or interactive mode. The resulting set of programs we have termed DYNAPRINT can be applied to any standard DYNAMO model. Not having access to the internal structure of DYNAMO, DYNAPRINT processes the standard print file produced by DYNAMO (as in Figure 4.1)

The data base loading program constructs a variable definition key, flexible enough to handle both single variables and DYNAMO arrays, based on the variable names at the top of the print file. The only restriction is that the user includes only one variable or array on each DYNAMO print card. The number and order of the variable names is then used by the program as a key to process the scale factors and variable solution values. The variable definition key and the data are then written to separate random access files, using the standard features of the UNIVAC FORTRAN compiler.

The data base retrieval routine is written to accept user input in free format and allows the user to produce a variety of reports. To print macroeconomic variables such as real GNP (RGNP) and the inflation rate (INFR), with DYNAPRINT the user simply types:

SHOW RGNP INFR

The procedure then prints the definition of both variables, followed by two columns of time series output after a column of dates. For arrays the program will automatically print time series in serial for each element of the array (e.g., production over time of each of the ERDYM sectors). In addition to the SHOW command, a comparison feature is available to allow side-by-side comparison of variables from alternative simulations.

Most of the tables in the following two chapters were produced with DYNAPRINT. The user's guide to the model provides complete instructions on how to use DYNAPRINT and the files it generates. Since many of the command files have been generated for the work in this study, the user in most cases will need to type only a single command to produce a standard summary report for a specific simulation.

4.3 MODEL INITIALIZATION

Initialization of a model as large as ERDYM is a complex task. There are several objectives to the initialization. First, the values of the model variables must be both internally consistent and must also correspond reasonably to historical statistics. Second, the variables must be defined so that a reasonable growth equilibrium is established. As our experience with the model indicates, achieving an approximate historical solution for the final few periods does not assure that the model will reasonably track the longer term trends of the economy. The decision to rely heavily on the National Income and Product Accounts and associated input-output accounting framework aids significantly in achieving an internally consistent model solution for the base period. Although the original P-R version of the model did employ the 1967 U.S. input-output table, their choice of data sources for other industry variables--employment, indirect tax rates, etc.--could have been improved so as to make the overall system internally more consistent. In trial simulations, this resulted in large changes in certain variables over the first few time periods, although the model eventually would move onto a stable growth trajectory. However, the lack of consistency among the original model variables made it difficult to interpret many aggregate results in light of familiar GNP accounts.

4.3.1 Sector Production and Prices

Conceptually, two familiar input-output accounting relationships must be satisfied in the base period. The first relates to production, the second to final demand; algebraically we have:

$$x_i = \quad A_{ij}x_j + f_i \qquad (4.1)$$

where

x_i = gross output in sector i

A_{ij} = input-output coefficient, the amount of input i required per dollar's worth of production of output j

f_i = final demand for sector i

Equation (4.1) simply states that sectoral production (x_i) is composed of output sold to other industries for use in production and of sales to final demand. When the input-output framework of Equation (4.1) is made consistent with the national accounts, the sum over i of f_i is Gross National Product.

The second accounting relationship involves value added and sectoral prices as shown below:

$$p_j = A_{ij} p_i + v_j \qquad (4.2)$$

where

p_j = output price of sector j
A_{ij} = input-output coefficient, as defined for (4.1)
v_j = value added--labor compensation, indirect business taxes, and profit-type income--per unit of output

Equation (4.2) relates the output price in each sector to intermediate input costs ("material" costs) plus the cost of primary factors of production (including indirect business taxes). Again, if the input-output system is consistent with the national accounts, the sum of the v_j components can be interpreted as GNP as measured from the income side. In the National Income and Product Account, the value added in each industry (v_j) is termed Gross Product Originating (GPO).

Initializing an equilibrium-type model so as to satisfy Equations (4.1) and (4.2) is not difficult, especially if the base period of the model corresponds to a year of a published input-output table. Converting the production flow to input-output coefficients and using the published final demand by sector is a simple matter of solving the (Leontief) equation for sectoral outputs. The use of Equation (4.2), after the conversion of income flows to coefficients, yields a price vector, P_j, whose values are all unity in the base period. Thus, the model is internally consistent and, by definition, agrees with the published national accounts in the base period.

To the extent possible, the use of the input-output accounting framework in Equations (4.1) and (4.2) guided much of the effort to initialize ERDYM. The choice of 1972 as the base year of the model was strongly influenced by the existence of the official Commerce Department table for the year. Section A.1

of Appendix A describes the aggregation of the FEMA Input-Output Table (based directly on the Commerce Department Table) to the 11-sector ERDYM classification. Section A.1 also describes how the final demands by sector for government, exports, and imports were also taken from this table.

For a number of reasons, a precise solution to Equations (4.1) and (4.2) was not possible in the base period of the model. (That is, the input-output framework of the model does not generate outputs identical to the 1972 table, and the sectoral prices are not all one in the base period.) On the production side [Equation (4.1)] there are two major causes of these discrepancies. The first relates to the specification of several of the final demand components. The second reason involves the way the lags are specified within the model and the way in which DYNAMO initializes the system.

With respect to the final demands, lack of resources precluded the calibration of the base period inventory change and consumption figures to exactly match the values from the 1972 table. In addition, in the fullblown input-output accounting framework, investment by industry is converted into final demand by capital goods sectors by use of what is termed a "capital distribution" matrix. In ERDYM, this process is simplified by collapsing the production of all capital goods into one sector (sector five). The distortion resulting from this assumption also contributes to the discrepancies in the final demand vector.

In addition to the discrepancies caused by the specification of final demand, the dynamic character of the model also introduces some error when one attempts to generate the historical production values within the model. In ERDYM, production does not match demand instantaneously, but rather depends upon planned production resulting from previous demands. In the process of setting the various production and inventory lags in the model, some slippage occurs in the translation of historical final demand to historical production. This slippage is unavoidable since there are no historical "data" on the many production-related variables in the model, only on realized sales to final demand and total production.

As a crude means of adjusting for the discrepancies caused from the two sources, an adjustment vector (ADJFD) was introduced which scales the <u>total</u> demand in the first period of the model to yield production figures that approximately match the 1972 published data. These factors generally range between .95 and 1.05. The resulting production magnitudes produced by the model are compared to the historical data in Table 4.1.

Discrepancies on the price side stem from analagous causes. First, some error is introduced as an imperfect correspondence was achieved between historical data and model-generated values for other profits, depreciation, and interest charges by sector. Another thorny problem is the return to proprietors in the medical service, construction, and service sectors. On the price side as well as the production side, the specification of behavioral lags necessarily introduced some errors. For instance, prices depend on perceived cost, rather than actual cost; perceived cost is a (exponential) smoothed function of lagged cost.

Table 4.1 shows the values of the sectoral price deflators produced by the model in the first period of the baseline historical simulation. For most sectors, the values are within five percent of the ideal value of 1.0. This level of correspondence was judged sufficiently accurate, so that current dollar magnitudes in subsequent periods can be compared with actual historical data.

4.3.2 Other Variables

The initialization of other variables to a 1972 base in the model was fairly straightforward, since these variables do not display the degree of interdependency that characterizes sectoral production and prices. As in the original P-R version, sources for many of these variables are simply cited in the model source code, as can be found in Volume III of this report. Other variables for which significant computation was required are discussed in Appendix A. This principally covers transfer payments, capital stocks, and monetary aggregates.

Table 4.1. Production and Price Initialization by Sector

		Actual Production (Billion 1972$)	Computed Production (Billion 1972$)	Computed Price Deflator
1.	Metals	62.2	61.2	1.032
2.	Non-metals	23.9	22.6	.969
3.	Energy Products	111.2	109.4	.961
4.	Non-fuel Consumable Materials	184.4	177.9	1.032
5.	Capital Goods	246.8	237.4	.959
6.	Building/Construction	165.9	160.1	.974
7.	Consumer Goods	88.0	84.4	.969
8.	Agriculture	201.9	197.2	.967
9.	Medical Services	55.3	55.1	1.083
10.	Transportation	76.6	76.4	1.059
11.	Services	747.7	730.1	.941

5.0 HISTORICAL SIMULATIONS

This chapter presents results of several simulations of the model over the period 1972-1984. These simulations are designed to show the growth characteristics of the model under normal conditions and to demonstrate that the model tracks historical performance of the economy with reasonable accuracy. The first part of this chapter reports these historical simulations. A second objective of this chapter is to show the sensitivity of the model to several key policy options. As reported in Chapter 3, the model can be simulated with a variety of monetary policy functions. The second part of this chapter reports two alternative simulations that alter these policy functions--in one case by changing the weights applied to the unemployment and inflation targets, in another by applying a strict monetarist reserve growth rule.

5.1 RESULTS OF HISTORICAL SIMULATIONS

The model results for the "baseline" simulation are shown for key macroeconomic variables in Table 5.1. Before discussing the values of the variables themselves, some discussion of the table format may be useful. The table reproduces the computer output from the DYNAPRINT utility program, described in Section 4.2. The printing interval is annual, starting with the first period of the simulation, 1972.00. The actual solution interval of ERDYM is .0625. Each year consists of 16 periods, and the report in Table 5.1 shows the values of each of the variables for the first period of each year. For flow variables (GNP aggregates), the magnitudes are expressed at annual rates, as the definition key over the table indicates. The values of most historical variables have been initialized to 1972 annual averages; accordingly, for historical comparisons we have generally interpreted the values in Table 5.1 to correspond to annual averages. In most cases, this assumption is fairly reasonable, except in cases where the variable displays show sharp year-to-year changes.

By looking at Table 5.1 and succeeding tables, the reader should continually be aware of the exponent that is printed at the top of each

TABLE 5.1. Key Macroeconomic Variables in Baseline Simulation

RGNP	REAL GROSS NATIONAL PRODUCT (1972$/YR)
PGGNP	PERCEIVED GROWTH OF GNP (FRACTION/YEAR)
GNP	GROSS NATIONAL PRODUCT ($/YEAR)
TPDE72	PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)
TSTR72	NONRESIDENTIAL STRUCTURES (1972$/YEAR)
HBC	HOUSEHOLD BUILDING CONSTRUCTED (UNITS/YEAR)
UERATE	UNEMPLOYMENT RATE (FRACTION)
INFR	INFLATION RATE (FRACTION/YEAR)

PER	TIME	RGNP	PGGNP	GNP	TPDE72	TSTR72	HBC	UERATE	INFR
EXPONENT - -)		9.0000	-3.0000	9.0000	6.0000	6.0000	6.0000	-3.0000	-3.0000
1	1972.00	1191.200	9.529	1191.700	77970.000	44698.000	62817.000	50.127	59.650
2	1973.00	1224.300	20.685	1265.500	84348.000	44731.000	59303.000	59.941	47.959
3	1974.00	1252.100	21.832	1367.600	82477.000	45863.000	52760.000	68.771	57.431
4	1975.00	1276.200	19.796	1462.800	79715.000	46177.000	52448.000	76.737	42.917
5	1976.00	1317.200	28.743	1579.100	85114.000	46986.000	59650.000	70.141	48.099
6	1977.00	1354.000	27.176	1707.500	86325.000	47494.000	53666.000	69.668	50.308
7	1978.00	1384.800	24.377	1831.200	85213.000	47803.000	53758.000	71.311	46.625
8	1979.00	1423.800	26.641	1974.200	85859.000	47755.000	52713.000	68.126	48.612
9	1980.00	1458.500	25.217	2141.900	84711.000	47104.000	49426.000	66.250	57.002
10	1981.00	1495.800	24.908	2313.500	81422.000	45872.000	45978.000	65.250	50.267
11	1982.00	1526.700	21.852	2480.400	78822.000	43891.000	42978.000	65.581	49.435
12	1983.00	1549.200	16.516	2644.500	77477.000	41687.000	41168.000	68.984	49.299
13	1984.00	1571.700	15.254	2818.800	78937.000	38837.000	44899.000	70.011	49.726
14	1985.00	1604.900	19.161	3032.400	83612.000	37772.000	47427.000	64.950	54.859
15	1986.00	1634.500	18.217	3278.900	85906.000	37040.000	43699.000	59.891	61.750
16	1987.00	1644.400	10.710	3508.300	84405.000	36982.000	41931.000	64.870	60.694
17	1988.00	1671.500	14.703	3799.100	83109.000	36914.000	41453.000	66.412	64.074
18	1989.00	1698.200	15.318	4122.500	82566.000	36475.000	40274.000	68.974	66.238
19	1990.00	1722.600	14.536	4467.400	82870.000	35819.000	40671.000	71.573	65.974
20	1991.00	1749.500	15.322	4830.600	84888.000	35222.000	43496.000	73.040	61.882
21	1992.00	1780.500	16.805	5227.700	88533.000	35029.000	46438.000	72.327	61.338
22	1993.00	1811.100	17.012	5646.600	91735.000	35607.000	47801.000	71.676	59.757
23	1994.00	1840.900	16.290	6085.500	94165.000	37291.000	49566.000	73.620	58.084
24	1995.00	1867.200	15.101	6527.200	97630.000	38868.000	56448.000	76.458	55.584

TABLE 5.1. (cont'd)

GIR	GOVERNMENT INTEREST RATE (FRACTION/YEAR)
IDOT	RATE OF CHANGE OF GIR (FRACTION/YR)
BINTR	BUSINESS INTEREST RATES (FRACTION/YEAR)
MINTR	MORTGAGE INTEREST RATES (FRACTION/YEAR)
DEMDEP	TOTAL DEMAND DEPOSITS ($)
RBASE	MONETARY BASE ($)
BORES	BORROWED RESERVES ($)
MPOL	MONETARY POLICY INDICATOR

PER	TIME	GIR	IDOT	BINTR	MINTR	DEMDEP	RBASE	BORES	MPOL
EXPONENT - ->		-3.0000	-3.0000	-3.0000	-3.0000	9.0000	9.0000	6.0000	0000
1	1972.00	44.000	-40.000	55.000	76.000	177.100	24.600	194.00(	.652
2	1973.00	44.440	10.824	55.400	76.330	184.560	26.910	-1068.700	.788
3	1974.00	51.780	4.466	62.000	81.830	195.630	28.260	-874.700	.899
4	1975.00	45.150	-29.856	56.030	76.860	210.100	30.480	-1066.900	1.236
5	1976.00	30.890	14.638	45.450	60.370	249.320	36.730	-1821.700	.823
6	1977.00	43.040	7.641	56.390	69.490	266.270	38.660	-1383.900	.843
7	1978.00	45.090	-.548	58.230	71.020	285.340	41.250	-1307.400	.975
8	1979.00	49.160	8.481	61.900	74.080	306.390	44.030	-1136.300	.837
9	1980.00	59.380	11.847	71.090	81.740	324.770	46.150	-685.600	.790
10	1981.00	70.840	9.824	81.410	90.340	343.630	48.260	-150.300	.812
11	1982.00	79.180	6.519	88.910	96.590	361.490	50.350	259.800	.875
12	1983.00	82.830	-1.809	92.200	99.330	379.830	52.730	447.600	1.045
13	1984.00	78.220	-5.397	88.050	95.870	401.690	56.040	194.800	1.090
14	1985.00	77.890	8.225	87.750	95.630	428.370	59.790	180.400	.870
15	1986.00	89.980	14.283	98.630	104.690	453.280	62.530	926.900	.743
16	1987.00	97.620	3.304	105.510	110.420	477.040	65.370	1419.700	.968
17	1988.00	101.880	5.917	109.340	113.620	509.400	69.600	1714.200	.932
18	1989.00	106.940	3.192	113.900	117.410	543.210	73.960	2085.100	.978
19	1990.00	107.860	-2.147	114.720	118.100	580.850	79.160	2154.500	1.059
20	1991.00	103.370	-5.786	110.680	114.730	624.370	85.640	1775.000	1.099
21	1992.00	98.800	-3.024	106.570	111.300	673.660	92.950	1362.600	1.056
22	1993.00	96.010	-2.257	104.060	109.220	725.380	100.460	1091.100	1.042
23	1994.00	92.460	-7.556	100.870	106.550	779.040	108.350	715.000	1.113
24	1995.00	78.130	-21.642	87.970	95.810	842.200	118.820	-914.500	1.227

TABLE 5.2. Comparison of Alternative Policy Target Weights

Base: .55 (UERATE)/.45 (INFR)
Alt: .50 (UERATE)/.50 (INFR)

RGNP REAL GROSS NATIONAL PRODUCT (1972$/YR)
UERATE UNEMPLOYMENT RATE (FRACTION)
INFR INFLATION RATE (FRACTION/YEAR)

PER	TIME	BAS- RGNP	ALT- RGNP	DIFF	BAS-UERATE	ALT-UERATE	DIFF	BAS- INFR	ALT- INFR	DIFF
EXPONENT - ->		9.0000	9.0000	9.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000	-3.0000
1	1972.00	1191.200	1191.200	.000	50.127	50.127	.000	59.650	59.650	.000
2	1973.00	1224.300	1224.200	-.100	59.941	59.938	-.003	47.959	48.057	.098
3	1974.00	1252.100	1251.000	-1.100	68.771	69.460	.689	57.431	54.885	-2.546
4	1975.00	1276.200	1273.800	-2.400	76.737	78.464	1.727	42.917	39.718	-3.199
5	1976.00	1317.200	1313.300	-3.900	70.141	73.056	2.915	48.099	43.433	-4.666
6	1977.00	1354.000	1350.600	-3.400	69.668	70.891	1.223	50.308	46.930	-3.378
7	1978.00	1384.800	1382.800	-2.000	71.311	71.910	.599	46.625	42.943	-3.682
8	1979.00	1423.800	1420.900	-2.900	68.126	69.067	.941	48.612	43.944	-4.668
9	1980.00	1458.500	1455.700	-2.800	66.250	67.529	1.279	57.002	51.929	-5.073
10	1981.00	1495.800	1493.000	-2.800	65.250	66.316	1.066	50.267	45.198	-5.069
11	1982.00	1526.700	1522.200	-4.500	65.581	66.375	.794	49.435	45.885	-3.550
12	1983.00	1549.200	1546.200	-3.000	68.984	69.597	.613	49.299	46.637	-2.662
13	1984.00	1571.700	1577.700	6.000	70.011	67.740	-2.271	49.726	49.212	-.514
14	1985.00	1604.900	1612.300	7.400	64.950	62.423	-2.527	54.859	55.615	.756
15	1986.00	1634.500	1639.800	5.300	59.891	60.502	.611	61.750	60.167	-1.583
16	1987.00	1644.400	1635.900	-8.500	64.870	66.975	2.105	60.694	57.506	-3.188
17	1988.00	1671.500	1658.900	-12.600	66.412	70.318	3.906	64.074	55.462	-8.612
18	1989.00	1698.200	1693.800	-4.400	68.974	68.665	-.309	66.238	58.184	-8.054
19	1990.00	1722.600	1721.100	-1.500	71.573	70.355	-1.218	65.974	61.743	-4.231
20	1991.00	1749.500	1744.300	-5.200	73.040	72.959	-.081	61.882	60.624	-1.258
21	1992.00	1780.500	1770.100	-10.400	72.327	75.435	3.108	61.338	54.352	-6.986
22	1993.00	1811.100	1796.500	-14.600	71.676	77.431	5.755	59.757	50.914	-8.843
23	1994.00	1840.900	1824.400	-16.500	73.620	79.251	5.631	58.084	49.825	-8.259
24	1995.00	1867.200	1852.900	-14.300	76.458	79.889	3.431	55.584	55.482	-.102

TABLE 5.2. (cont'd)

MPOL MONETARY POLICY INDICATOR
BINTR BUSINESS INTEREST RATES (FRACTION/YEAR)
TPDE72 PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)

PER	TIME	BAS- MPOL	ALT- MPOL	DIFF	BAS- BINTR	ALT- BINTR	DIFF	BAS-TPDE72	ALT-TPDE72	DIFF
EXPONENT - ->		.0000	.0000	.0000	-3.0000	-3.0000	-3.0000	6.0000	6.0000	6.0000
1	1972.00	.652	.623	-.029	55.000	55.000	.000	77970.000	77970.000	.000
2	1973.00	.788	.755	-.033	55.400	55.660	.260	84348.000	84359.999	11.999
3	1974.00	.899	.882	-.017	62.000	63.480	1.480	82477.000	82149.999	-327.001
4	1975.00	1.236	1.280	.044	56.030	58.180	2.150	79715.000	78859.999	-855.001
5	1976.00	.823	.892	.069	45.450	43.280	-2.170	85114.000	84319.999	-794.001
6	1977.00	.843	.832	-.011	56.390	51.760	-4.630	86325.000	87250.000	925.000
7	1978.00	.975	.963	-.013	58.230	54.760	-3.470	85213.000	86930.000	1717.000
8	1979.00	.837	.854	.017	61.900	57.430	-4.470	85859.000	87590.000	1731.000
9	1980.00	.790	.795	.005	71.090	65.560	-5.530	84711.000	86670.000	1959.000
10	1981.00	.812	.831	.019	81.410	74.200	-7.210	81422.000	83899.999	2477.999
11	1982.00	.875	.889	.015	88.910	80.680	-8.230	78822.000	81270.000	2448.000
12	1983.00	1.045	1.015	-.030	92.200	83.320	-8.880	77477.000	79829.999	2352.999
13	1984.00	1.090	.906	-.184	88.050	82.670	-5.380	78937.000	81130.000	2193.000
14	1985.00	.870	.744	-.126	87.750	90.780	3.030	83612.000	84020.000	408.000
15	1986.00	.743	.724	-.019	98.630	103.760	5.130	85906.000	83819.999	-2086.001
16	1987.00	.968	1.089	.121	105.510	109.910	4.400	84405.000	81079.999	-3325.001
17	1988.00	.932	1.071	.140	109.340	104.240	-5.100	83109.000	80289.999	-2819.001
18	1989.00	.978	.910	-.068	113.900	106.180	-7.720	82566.000	83159.999	593.999
19	1990.00	1.039	.947	-.112	114.720	111.250	-3.470	82870.000	84659.999	1789.999
20	1991.00	1.099	1.047	-.052	110.680	112.960	2.280	84888.000	85090.000	202.000
21	1992.00	1.056	1.138	.082	106.570	108.390	1.820	88533.000	86359.999	-2173.001
22	1993.00	1.042	1.216	.175	104.060	99.260	-4.800	91735.000	90010.000	-1725.000
23	1994.00	1.113	1.256	.142	100.870	79.850	-21.020	94165.000	96359.999	2194.999
24	1995.00	1.227	1.235	.008	87.970	49.270	-38.700	97630.000	109159.999	11529.999

TABLE 5.3. Comparison of Alternative Growth Rates of Reserve Base

Base: 7.5 percent growth in reserve base
Alt: 8.0 percent growth in reserve base

RGNP REAL GROSS NATIONAL PRODUCT (1972$/YR)
GNP GROSS NATIONAL PRODUCT ($/YEAR)
TPDE72 PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)

PER	TIME	BAS- RGNP	ALT- RGNP	DIFF	BAS- GNP	ALT- GNP	DIFF	BAS-TPDE72	ALT-TPDE72	DIFF
EXPONENT - -)		9 0000	9 0000	9 0000	9 0000	9 0000	9 0000	9 0000	9 0000	9 0000
1	1972 00	1191 200	1191 200	000	1191 700	1191 700	[illegible]	77 970	77 970	000
2	1973 00	1223 400	1223 800	400	1262 200	1262 800	600	84 520	84 760	240
3	1974 00	1257 000	1258 000	1 000	1372 900	1377 000	4 100	85 070	85 760	690
4	1975 00	1289 300	1293 500	4 200	1493 100	1509 000	15 900	83 680	[illegible]	1 120
5	1976 00	1324 000	1330 800	6 800	1608 500	1637 900	29 400	82 670	83 920	1 250
6	1977 00	1364 300	1373 400	9 100	1736 700	1785 300	48 600	83 750	84 630	[illegible]
7	1978 00	1409 100	1421 700	12 600	1888 200	1966 400	78 200	85 820	86 070	250
8	1979 00	1459 500	1474 100	14 600	2082 200	2201 800	119 600	87 790	86 970	- 820
9	1980 00	1509 600	1522 300	12 700	2343 300	2502 600	159 300	87 950	85 870	-2 080
10	1981 00	1560 500	1570 100	9 600	2647 200	2834 800	187 600	85 300	82 820	-2 480
11	1982 00	1603 000	1602 100	- 900	2969 500	3184 000	214 500	81 680	79 750	-1 930
12	1983 00	1625 700	1618 900	-6 800	3323 600	3564 000	240 400	78 240	76 950	-1 290
13	1984 00	1630 600	1617 700	-12 900	3697 300	3953 000	255 700	74 730	74 020	- 710
14	1985 00	1603 200	1596 000	-7 200	4030 400	4318 000	287 600	71 330	71 000	- 330
15	1986 00	1607 400	1604 500	-2 900	4439 900	4769 100	329 200	67 360	67 990	630
16	1987 00	1614 400	1612 800	-1 600	4839 800	5201 800	362 000	66 410	67 990	1 580
17	1988 00	1620 500	1622 200	1 700	5169 500	5576 000	406 500	69 030	71 230	2 200
18	1989 00	1630 600	1632 100	1 500	5408 300	5860 100	451 800	75 490	77 930	2 440
19	1990 00	1642 300	1643 600	1 300	5610 700	6121 900	511 200	83 510	85 660	2 150
20	1991 00	1660 300	1661 500	1 200	5870 500	6431 100	560 600	92 210	94 830	2 620
21	1992 00	1688 000	1697 500	9 500	6155 800	6804 800	649 000	100 690	103 070	2 380
22	1993 00	1705 700	1715 600	9 900	6338 600	6897 200	558 600	107 220	109 710	2 490
23	1994 00	1715 800	1725 700	9 900	6261 100	6809 800	548 700	112 410	115 050	2 640
24	1995 00	1713 600	1718 700	5 100	6115 400	6639 900	524 500	113 510	113 790	280

TABLE 5.3. (cont'd)

UERATE UNEMPLOYMENT RATE (FRACTION)
INFR INFLATION RATE (FRACTION/YEAR)
BINTR BUSINESS INTEREST RATES (FRACTION/YEAR)

PER	TIME	BAS-UERATE	ALT-UERATE	DIFF	BAS- INFR	ALT- INFR	DIFF	BAS- BINTR	ALT- BINTR	DIFF
EXPONENT - -)		-3 0000	-3.0000	-3.0000	-3 0000	-3 0000	-3 0000	-3 0000	-3 0000	-3 0000
1	1972 00	50 130	50 130	000	59 650	59 650	000	55 000	55 000	000
2	1973 00	60 250	59 860	- 390	45 550	45 940	390	57 490	56 520	- 970
3	1974 00	65 260	64.300	- 960	63 170	66 210	3 040	55 900	54 420	-1 480
4	1975 00	68 710	66 090	-2 620	54 480	60 480	6 000	56 430	54 720	-1 710
5	1976 00	68 670	64 850	-3 820	46 070	52 300	6 230	59 220	58 480	- 740
6	1977 00	65 120	60 220	-4 900	47 590	56 200	8 610	59 850	61 420	1 570
7	1978 00	60 610	54 580	-6 030	53 860	65 890	12 030	59 190	62 660	3 470
8	1979 00	53.440	46 870	-6 570	66.920	81 800	14 880	64 750	71 890	7 140
9	1980 00	45 060	38 600	-6 460	90.130	97 800	7 670	76 120	84 440	8 320
10	1981 00	38 880	35 810	-3 070	86 950	92 610	5 660	90 030	98 170	8 140
11	1982 00	36 690	38 250	1 560	90 940	98 250	7 310	105 180	112 530	7 350
12	1983 00	41 470	43 930	2 460	101 090	104 000	2 910	120 170	126 110	5 940
13	1984 00	50 010	53 060	3 050	104 570	104 940	370	134 260	137 340	3 080
14	1985 00	63 660	66 730	3 070	101 630	99 760	-1 870	143 210	146 130	2 920
15	1986 00	76 150	76 630	480	91 840	91 590	- 250	153 570	152 610	- 960
16	1987 00	85 560	85 040	- 520	77 380	77 290	- 090	154 380	151 420	-2 960
17	1988 00	94 050	92 010	-2 040	55 570	58 040	2 470	144 650	141 000	-3 650
18	1989 00	99 640	97 220	-2 420	32 470	38 670	6 200	124 850	121 600	-3 250
19	1990 00	102 100	98 370	-3 730	32 560	39 120	6 560	104 020	100 330	-3 690
20	1991 00	99 210	93 990	-5 220	34 460	41 620	7 160	87 220	83 570	-3 650
21	1992 00	97 800	93 130	-4 670	31 140	28 570	-2 570	72 840	69 910	-2 930
22	1993 00	103 380	99 030	-4 350	7 340	-8 330	-15 670	59 060	54 430	-4 630
23	1994 00	114 950	110 870	-4 080	-20 600	-18 950	1 650	45 130	44 650	- 480
24	1995 00	129 720	127 370	-2 350	-21 500	-21 730	- 230	44 410	44 650	240

column. Thus, GNP is in fact in billions (10^9) and interest rates are reasonable when the scale factor of 10^{-3} is applied.

5.1.1 Macroeconomic Results

Real GNP (RGNP) in column one shows steady growth from 1972 to 1984. Variable PGGNP, which measures an annual growth rate in real GNP, reveals some slight cyclical variations. Although the growth rates do not turn negative, they do decline moderately in 1975 and throughout the 1980-83 period, roughly consistent with historical behavior. A graphical comparison of the baseline, and actual real GNP (in Figure 5.1) shows that, although the model does not catch the cyclical turning points, the trend growth over the 12-year period matches very closely. When analyzed from a standpoint of percentage differences, the maximum deviation is only 4.2 percent, well within the goal of ±20 accuracy.

The inflation rates generated by the model (INFR) employ a smoothing function provided by the DYNAMO language. We have chosen a period of .25 for the smoothing period. Based on this assumption, the inflation rates shown in Table 5.1 can be roughly interpreted as the quarterly inflation rates (on an annual basis) measured at the beginning of each year. Although the inflation rates peak during 1974 and they also rise again in 1980, the overall level of inflation rates is lower than the historical record (shown in Figure 5.2). The rates of inflation are strongly influenced by the parameters of the wage function in the model. These parameters have been chosen to yield reasonable inflation rates over the complete baseline solution, extending to the year 2005. A second cause of the deviation stems from the fact that none of the various shocks--price-wage decontrol, commodity shortages, and petroleum interruptions--experienced by the U.S. economy in the 1970s are reflected in the model in any way. Thus, the pattern of inflation rates shown can be roughly interpreted as the underlying rate of inflation in the absence of these shocks.

The values of nominal GNP in Table 5.1 of course reflect the pattern of general inflation. By 1983, the model underpredicted the nominal GNP by $750 billion in 1983, approximately 32 percent. This results directly from the underprediction of the inflation rate.

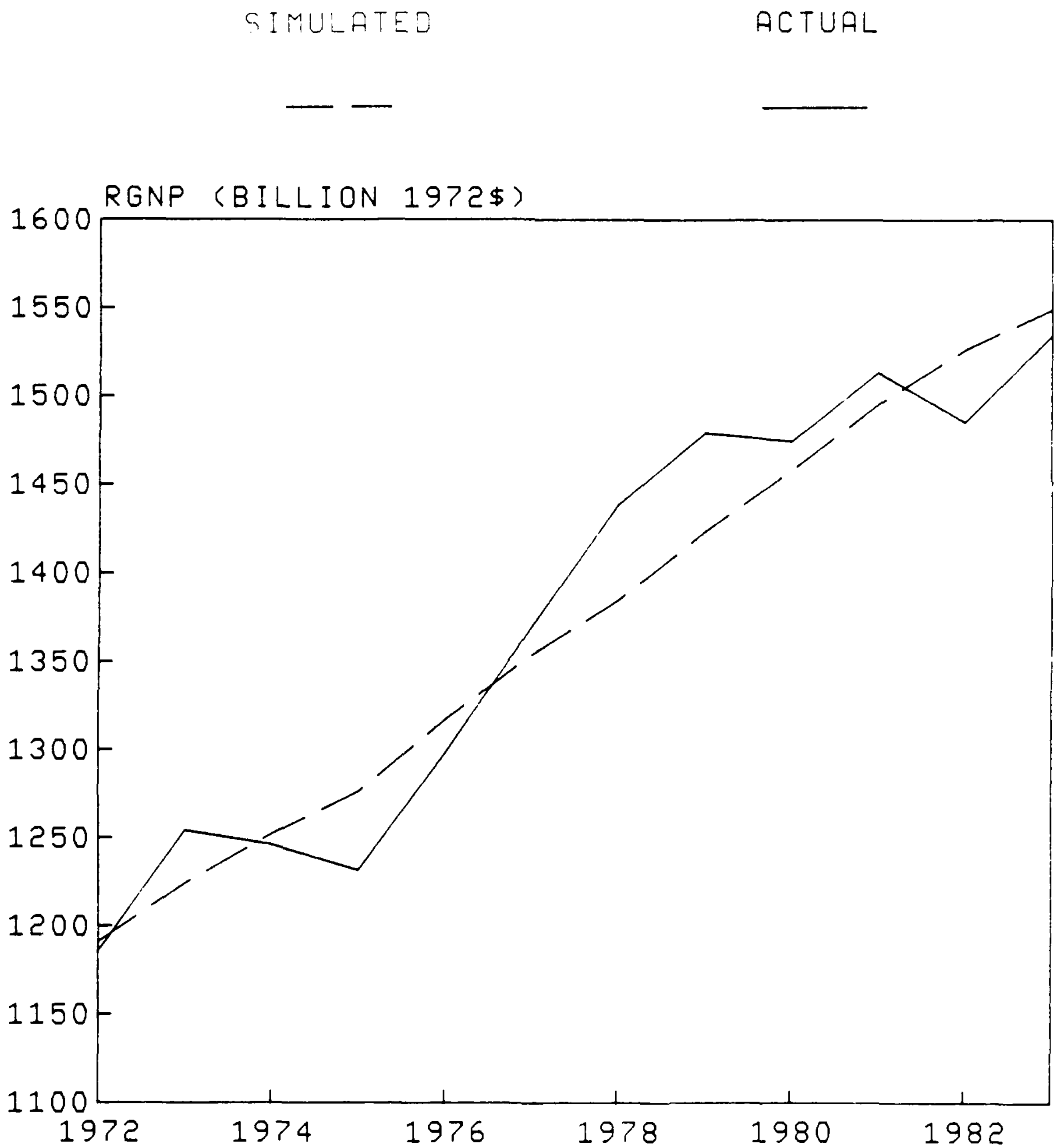


FIGURE 5.1. Real Gross National Product: Simulated and Actual, 1972-83

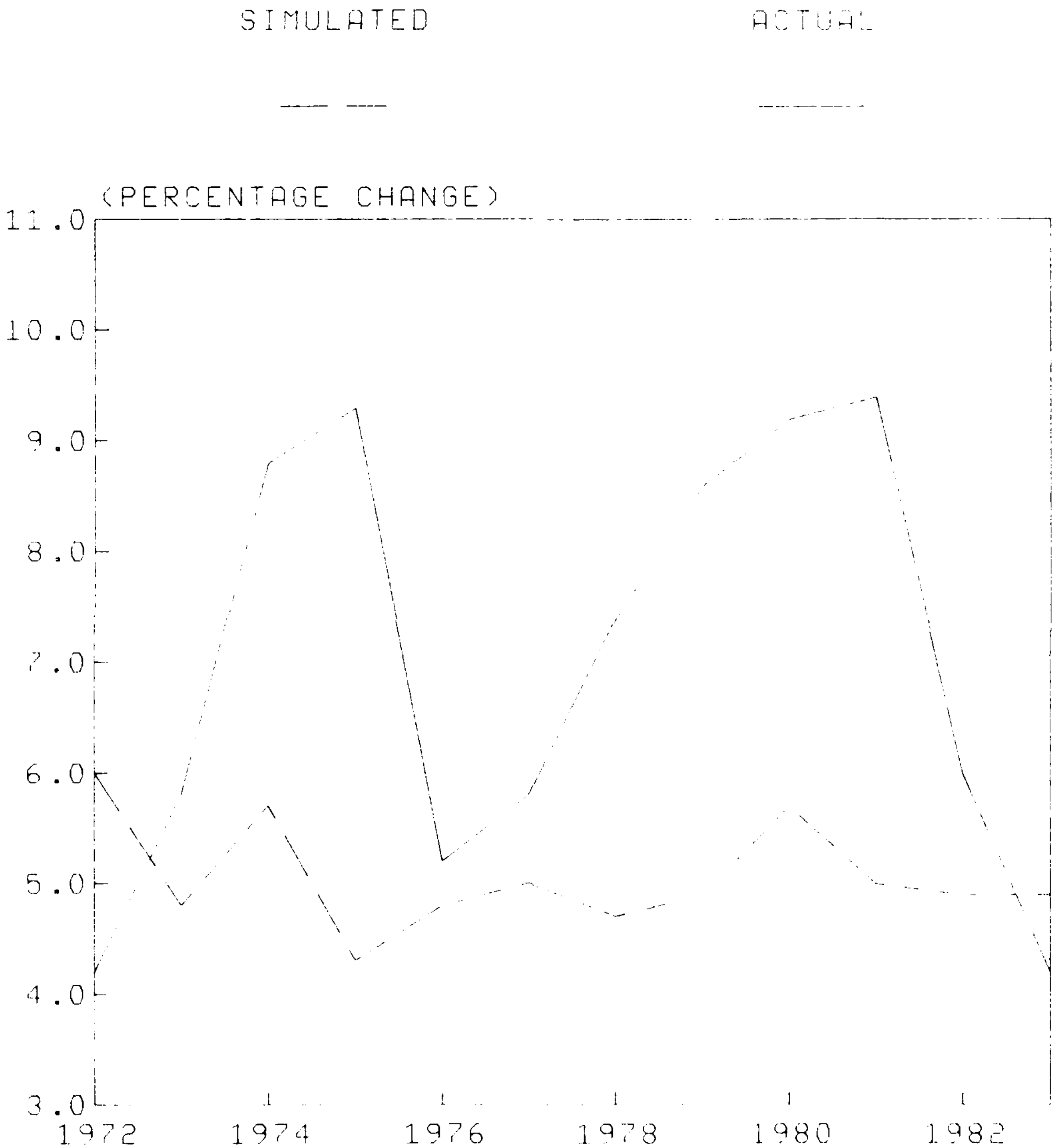


FIGURE 5.2. Inflation Rate (GNP deflator): Simulated and Actual, 19[illegible]-83

The unemployment rates correspond roughly with level of real GNP, but they do not vary a great deal owing to the fairly smooth trend growth. However, unemployment does respond to changes in the growth in GNP. The employment rate rises nearly a full percentage point in 1975 as the growth in real GNP slows compared to its change in the two prior years. A comparison of the unemployment rate from the model and the actual rates over 1972-83 is shown in Figure 5.3.

Each of the three investment series displays the general pattern of historical investment over the 1972-83 period, although the model underpredicts actual behavior. Residential housing (HBC) shows high levels of activity in 1972 and in 1973 with subsequent decline in 1974-75 that corresponds closely to the historical record. The model shows an upturn in 1977, which corresponds well with the magnitude of the actual value of 61.0 billion. Nonresidential structures investment shows little year-to-year variance; this pattern roughly corresponds to the historical values that range between 44 billion and 53 billion 1972 dollars over the 1972-83 period.

A comparison between actual and model-generated values for producers' durable equipment (PDE) is shown in Figure 5.4. The pattern is reasonably consistent for the first four or five years after which the model appears to underpredict by slightly more than 20 percent. More detailed analysis suggests several reasons why this may occur. First, the predictions of the sectoral output series, upon which the investment functions are tied, show some large errors in trend growth rates. The transportation sector, which is a large purchaser of PDE, is a case where the output is significantly underpredicted by the model. Secondly, the investment functions are not estimated, as for an econometric model, thus the variables describing planned output and adjustment periods are fixed by assumption rather than estimated from the data. This has the effect of not putting the investment in the proper growth equilibrium at the beginning of the simulation. Although the simulated PDE is lower than historical levels, longer run simulations show that PDE remains a fairly constant fraction of GNP on average. This is consistent with economic growth theory and vital to a balanced long-run growth path for ERDYM.

The three primary interest rates in the model are in the second panel of Table 5.1. As described in Chapter 3, the government bill rate (GIR) is the

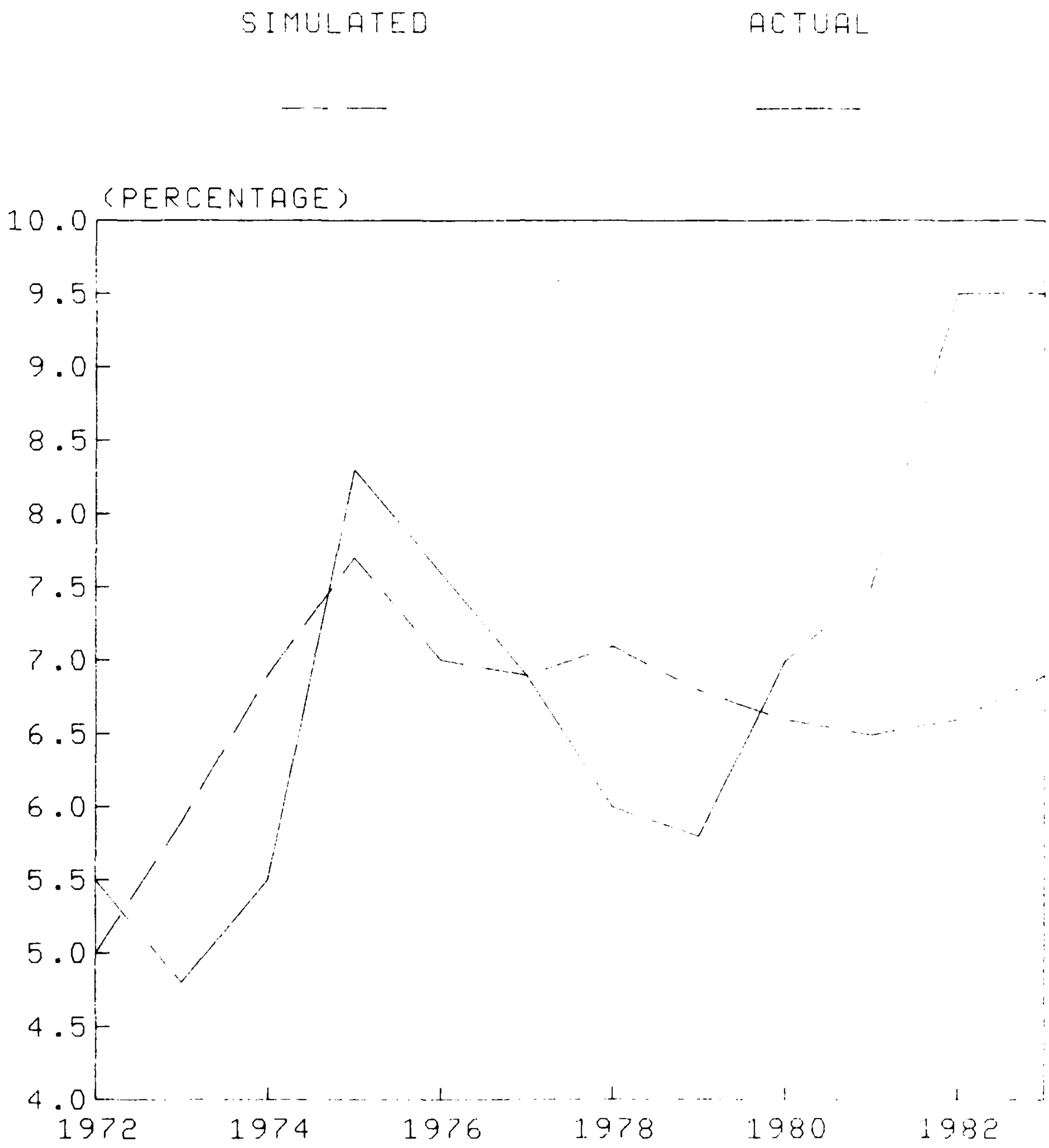


FIGURE 5.3. Unemployment Rate: Simulated and Actual, 1972-83

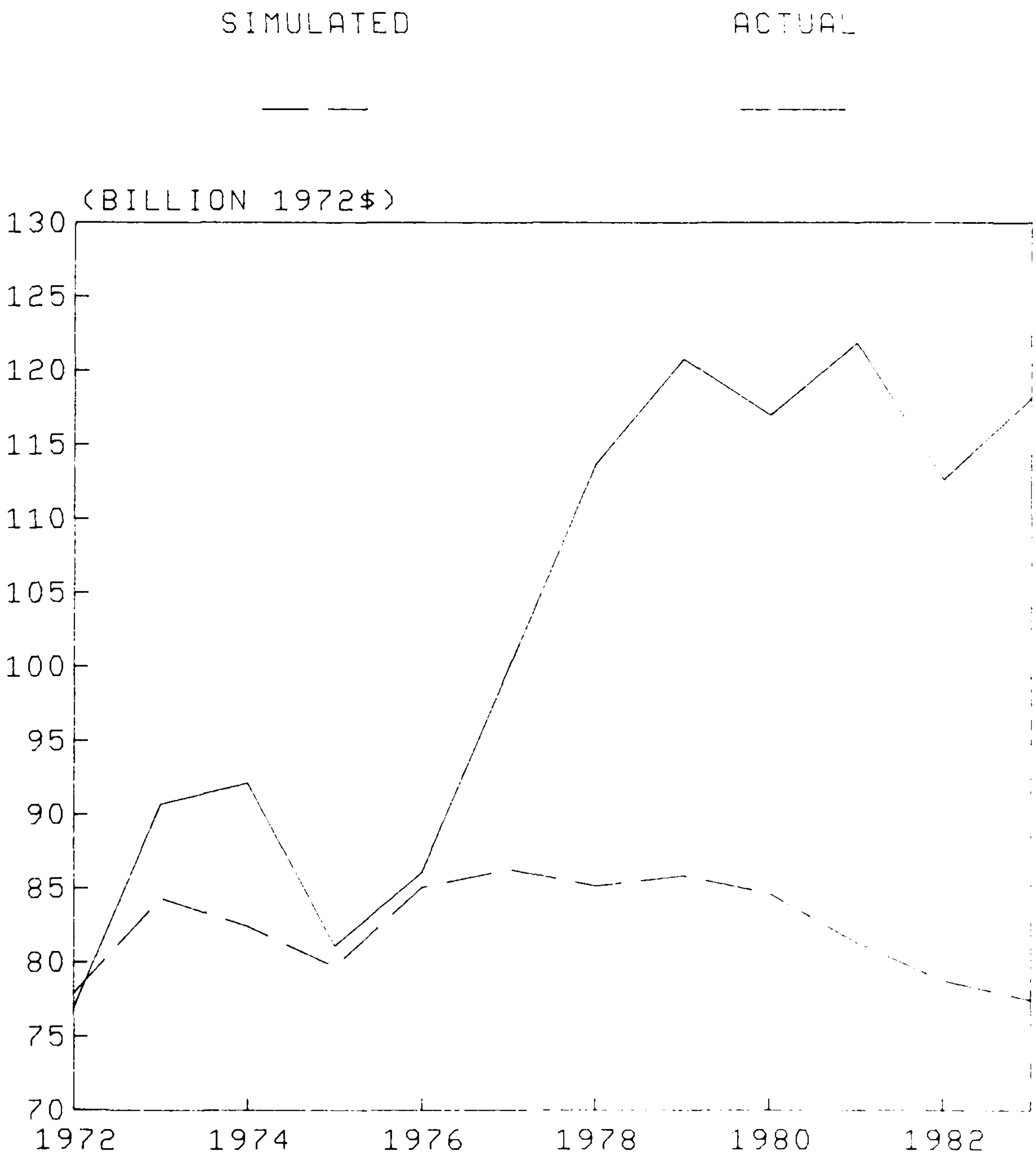


FIGURE 5.4. Producers' Durable Equipment: Simulated and Actual, 1972-83

key rate in the model. IDOT shows the rate of change of GRI in the first period of each year. The business rate (prime rate denoted BINTR) and the mortgage rate (MINTR) adjust at specified fractions of IDOT. For the simulation shown in this report, these fractions are .9 for BINTR and .25 for MINTR.

Figure 5.5 shows a plot of the 3-month historical bill rates (annual average) versus the values shown in Table 5.1. The pattern of interest rate movements shows some of the same cyclical variation as the history, although considerably attenuated. The link between the interest rates and investment shows up most clearly in 1980-83, as BINTR rises by approximately one percentage point per year, total PDE falls by some $2 to $3 billion per year.

The final set of variables in Table 5.1 relates to the monetary sector. As described in Chapter 3, the reserve base is initialized at the value of unborrowed reserves for the total commercial banking system. Total demand deposits are initialized at the value of published demand deposit component of the M1 money stock. The magnitude of the reserve base by 1983 exceeds actual reserves by some $130 billion. Primarily, this is due to the basic unitary income elasticity assumed for demand deposits in the model. However, in terms of the behavior of the model, the overprediction is not critical. The short-run changes in interest rates, which are the major linkage from the financial to the real sector, would not differ appreciably had a lower income elasticity been used. Since M1 is the single measure of the money stock available in the model, it was felt that the current specification, holding the money stock roughly proportional to nominal GNP, faciliates the interpretation of long-run simulations.

Positive values of borrowed reserves (BORES) indicate net borrowings from the Federal Reserve; negative values represent excess reserves. The change in reserve position influences the change in the government rate as described in Chapter 3. This relationship can be seen by comparing the values of BORES and IDOT in the table. The values of BORES do not exceed 5 percent of the reserve base in absolute terms over the 1972-84 period. This value is somewhat higher than actual experience, but this behavior is reasonable considering that the model does not have a completely developed set of interrelated financial markets nor does it attempt to model Federal Reserve discount policy. A major

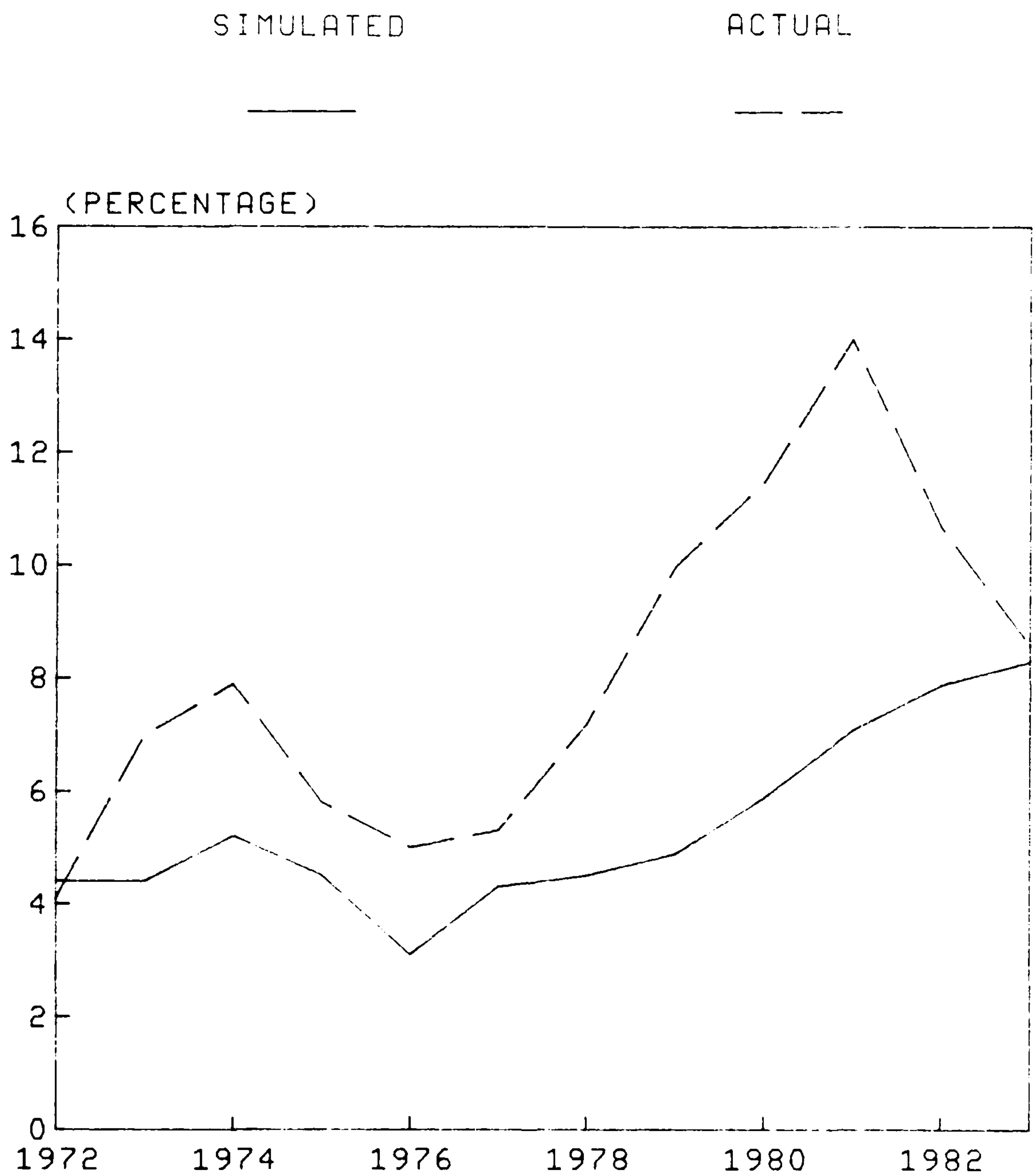


FIGURE 5.5. Three-month Treasury Bill Rate: Simulated and Actual, 1972-83

factor influencing the reserve position of the banking sector is the speed of adjustment of interest rates, and the attendant response in real economic activity. The maximum speed of adjustment is set to 4 percentage points per year. With the exception of the initial period of the model, the changes in GIR denoted by IDOT are all considerably less than this limit, suggesting that the real and financial sectors are reasonably close to a growth equilibrium.

The final variable shown in Table 5.1 is MPOL the monetary policy indicator. As described in Chapter 3, the growth in the reserve base can be specified to be either exogenous or related to a "reaction" function intended to represent central bank behavior. In the baseline simulation this reaction function (see Equation (3.1) is activated and thus MPOL shows the extent to which unborrowed reserves grow faster or slower than needed to satisfy the requirements of the banking systems. Values less than one represent contractionary policy; and vise versa for values exceeding one. The relationship between borrowed reserves and MPOL is clearly shown in the table. Comparing 1975 and 1976, for example, reveals that MPOL moves to the expansionary side, changing from 1.236 to .823. Excess reserves increase (BORES change from -$1066 million to -$821 million) and the government rate falls by one and a half a percentage point. Note that the MPOL function cycles throughout the 1972-84 period, as the central bank continually adjusts reserve growth to meet the desired targets here, set at 2.5 percent growth in GNP, six percent unemployment, and three percent inflation. Of course the model underestimates the magnitude of the actual cyclical behavior of 1972-84, because none of the exogenous shocks of the 70s were imposed; nevertheless, the endogenous cyclical behavior represented in the model may indeed be reflecting some elements of the real business cycle behavior of the U.S economy.

5.1.2 Industry Results

Figures 5.6 through 5.16 show the actual and the model-generated real gross output by sector over the period 1972-1982. Actual gross outputs are derived by aggregating 1972 constant dollar product values from the Bureau of Labor Statistics Economic Growth Model. Each of these series was scaled to match the 1972 production value as computed from the aggregated 1972 FEMA Input-Output table (see Appendix A).

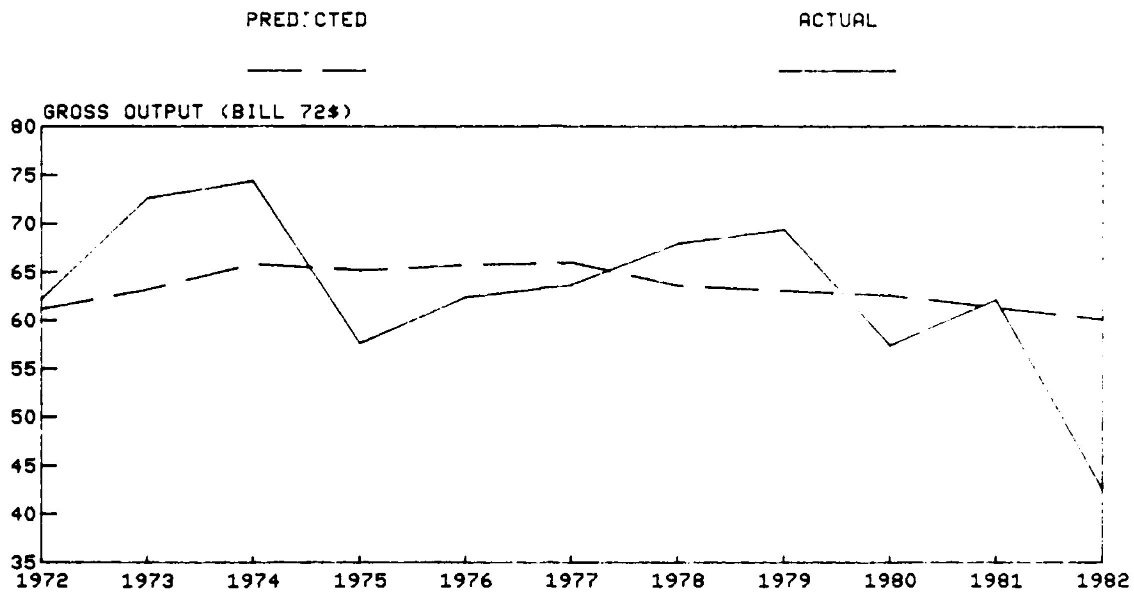


FIGURE 5.6. Metals: Simulated and Actual Output, 1972-1982

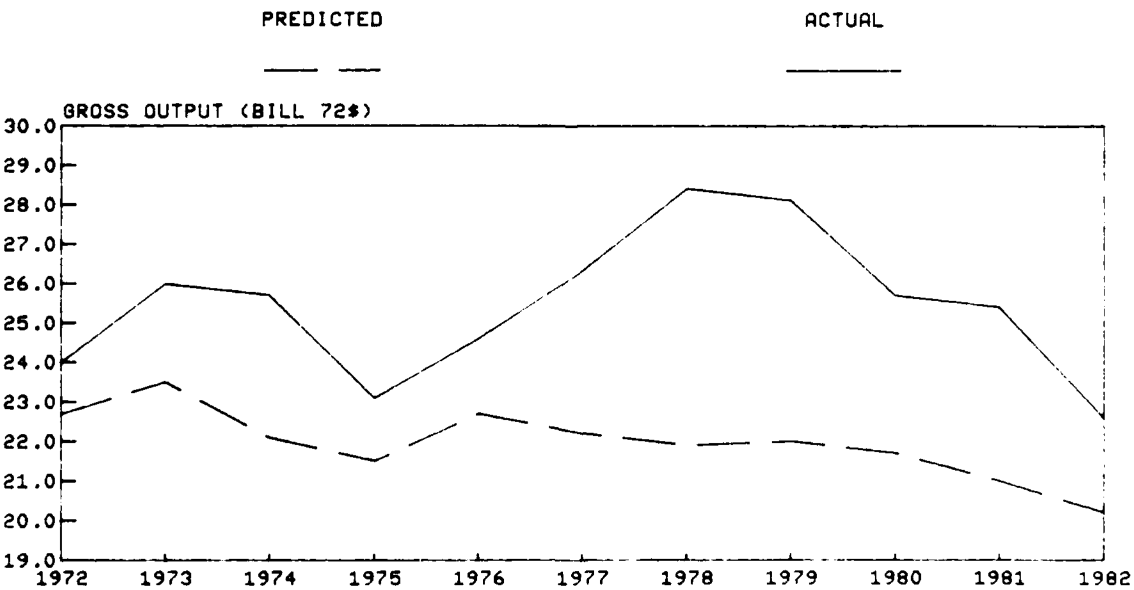
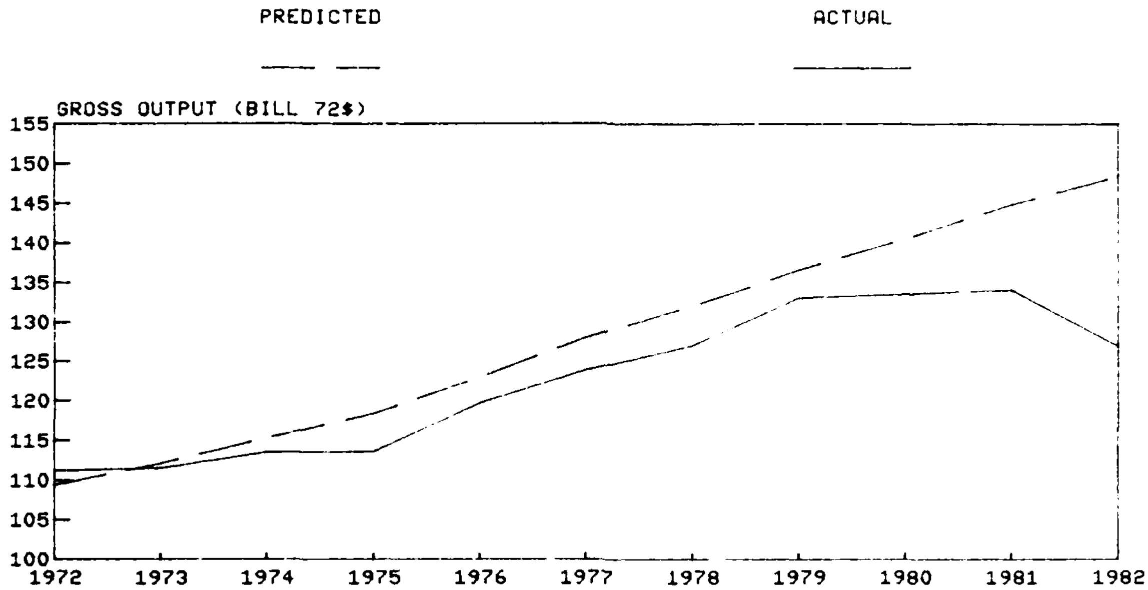
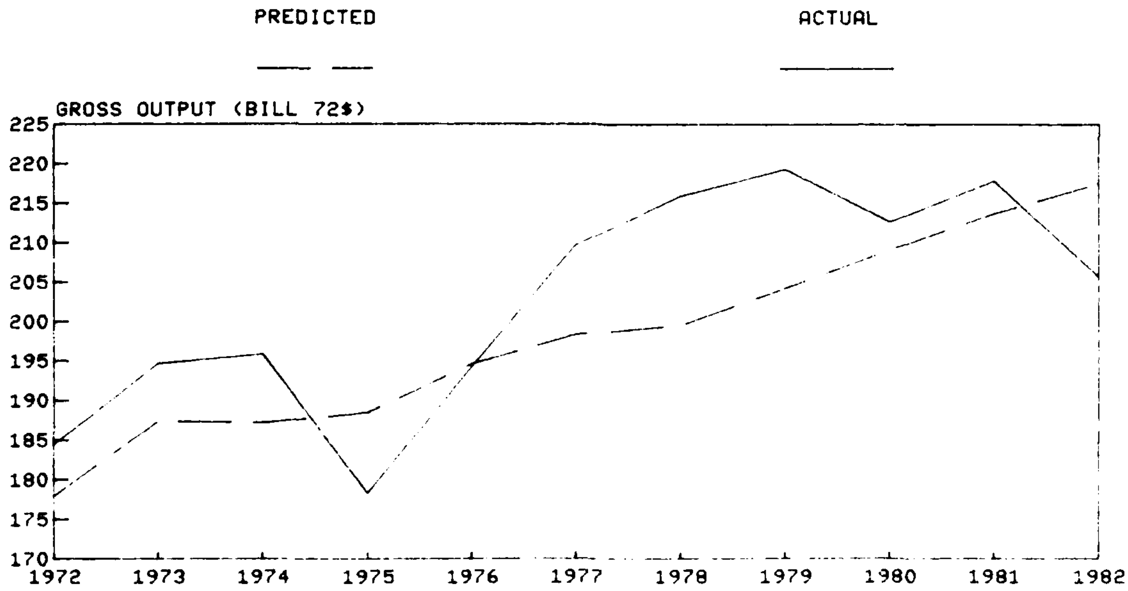


FIGURE 5.7. Non-metals: Simulated and Actual Output, 1972-1982



<u>FIGURE 5.8</u>. Energy Products: Simulated and Actual Output, 1972-1982



<u>FIGURE 5.9</u>. Non-fuel Materials: Simulated and Actual Output, 1972-1982

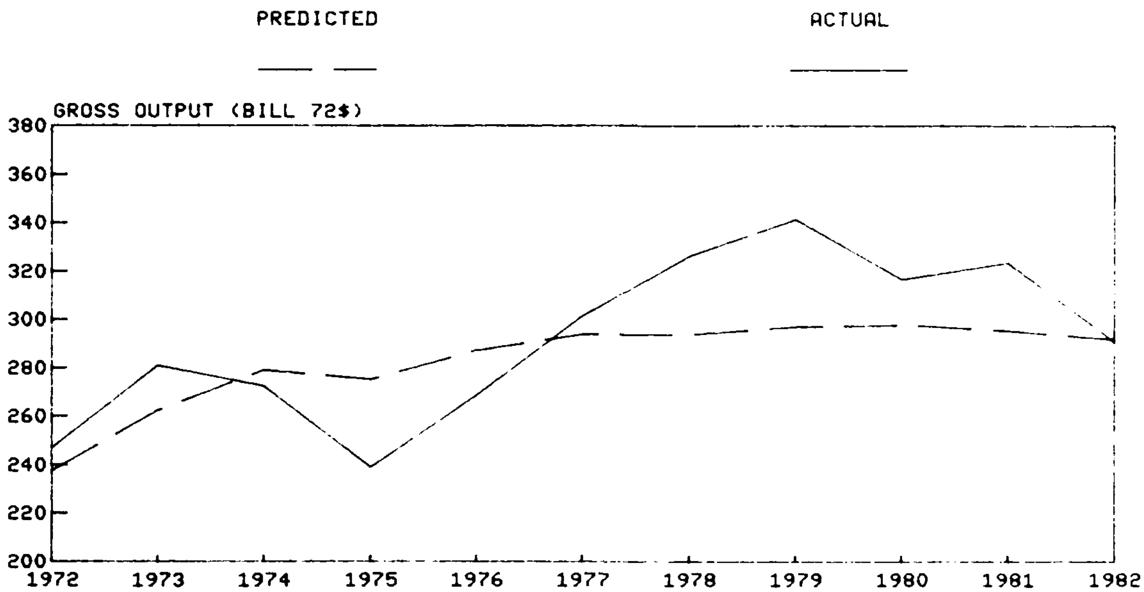


FIGURE 5.10. Capital Goods: Simulated and Actual Output, 1972-1982

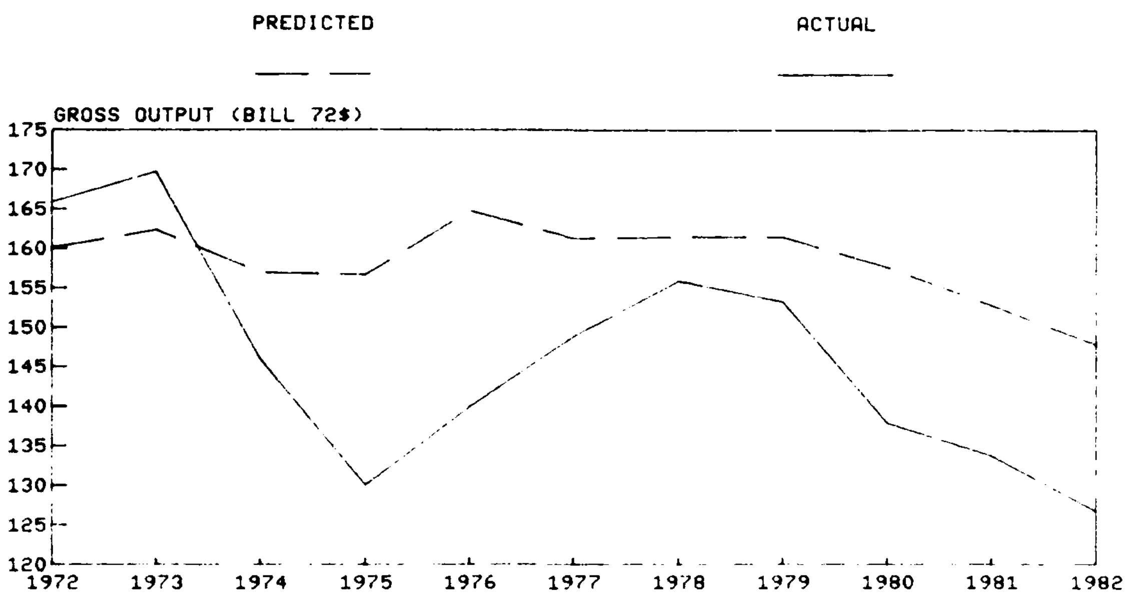


FIGURE 5.11. Construction: Simulated and Actual Output, 1972-1982

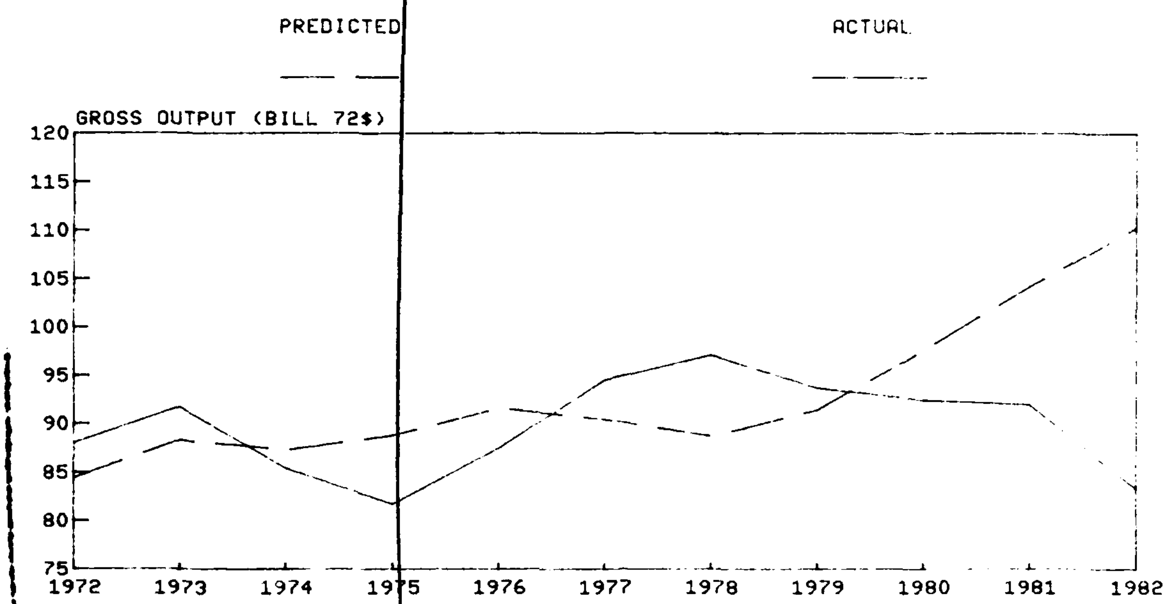


FIGURE 5.12. Consumer Goods: Simulated and Actual Outputs, 1972-1982

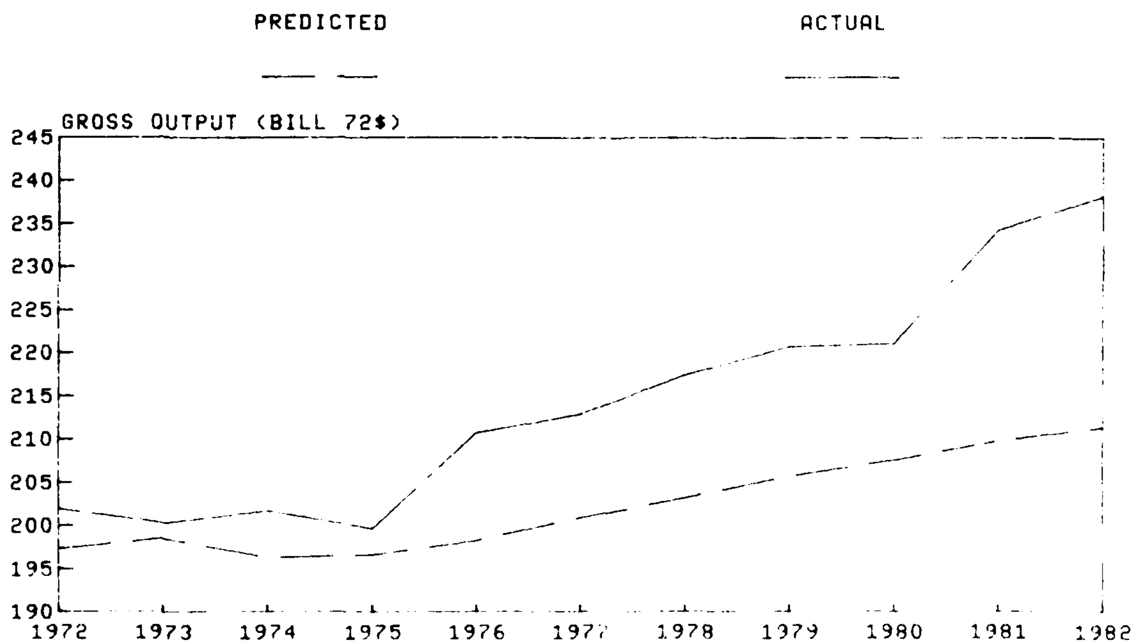


FIGURE 5.13. Agriculture: Simulated and Actual Outputs, 1972-1982

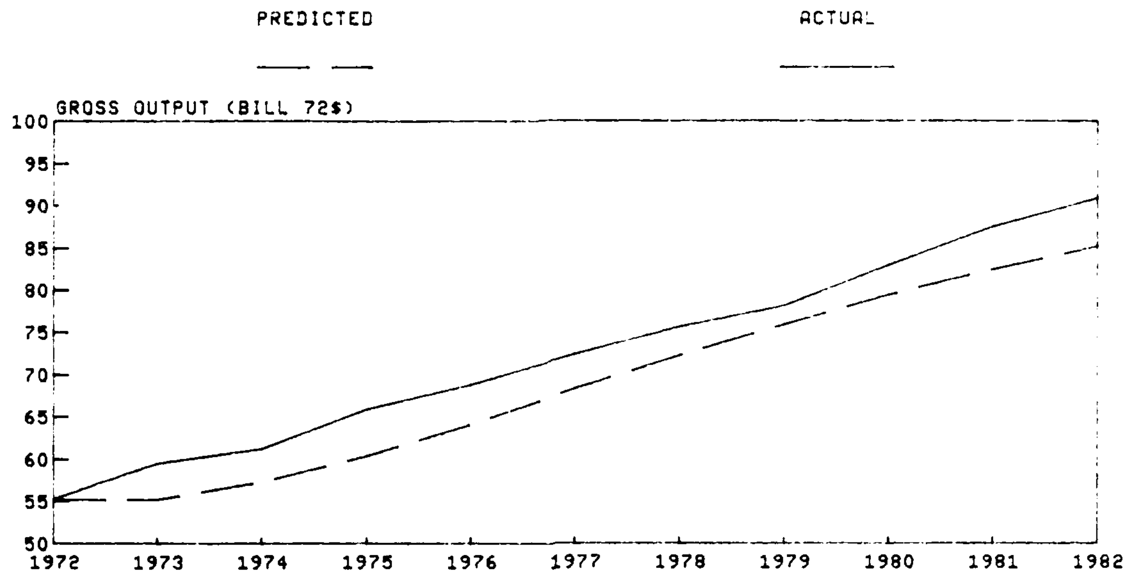


FIGURE 5.14. Medical Services: Simulated and Actual Outputs, 1972-1982

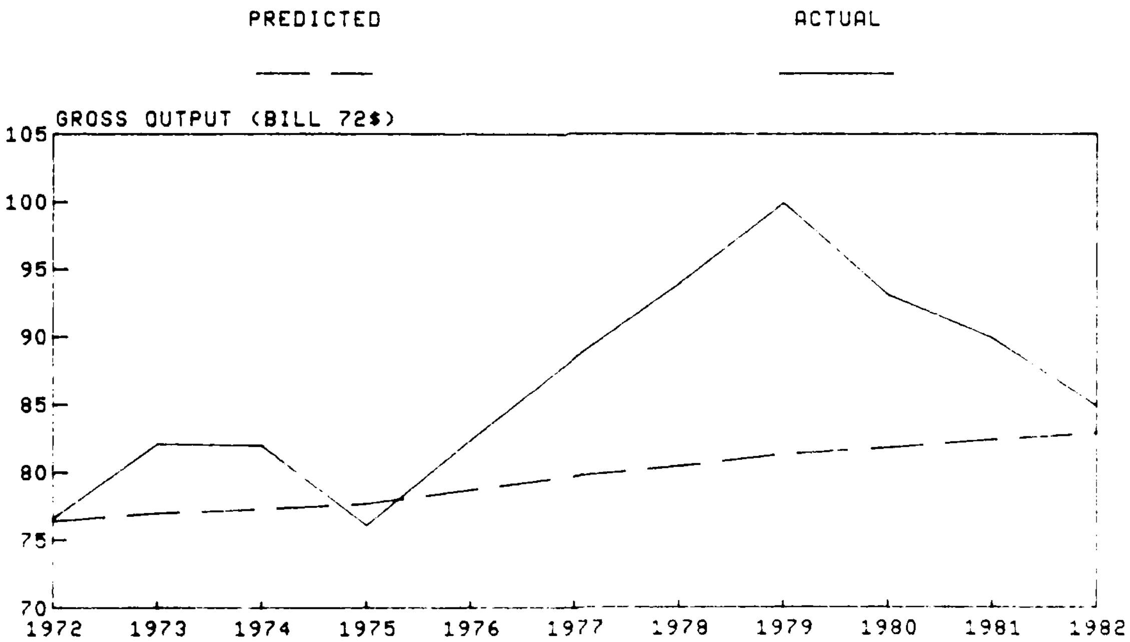


FIGURE 5.15. Transportation: Simulated and Actual Outputs, 1972-1982

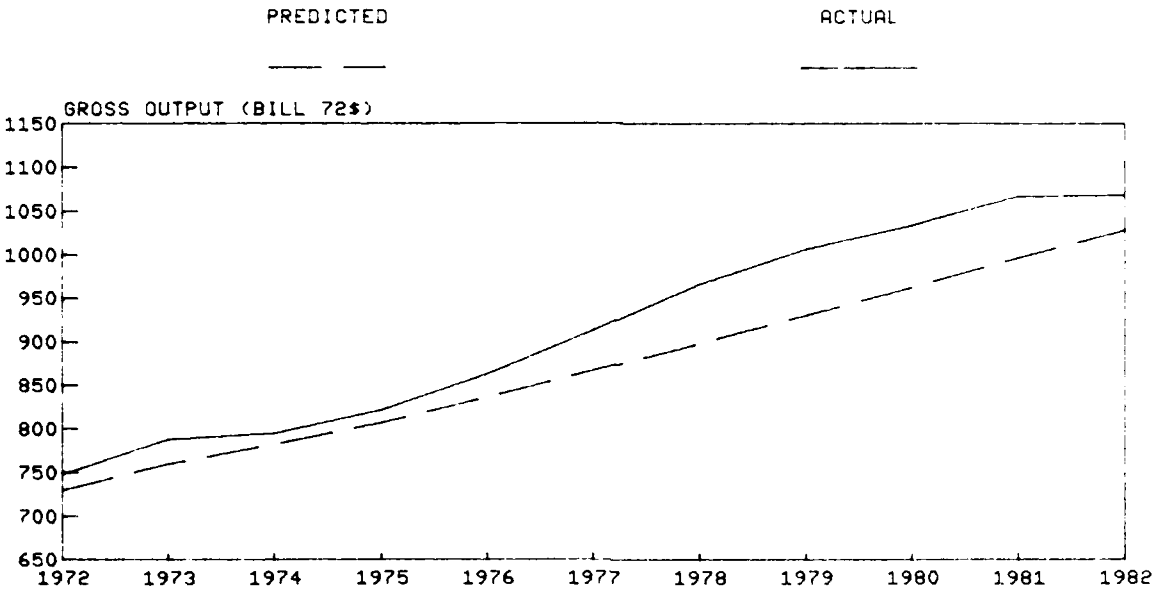


FIGURE 5.16. Trade and Services: Simulated and Actual Outputs, 1972-1982

The overall conclusion that can be drawn from these industry figures is this: at the disaggregated industry level, ERDYM simulates actual industry output with reasonable accuracy. There are instances when the tracking of individual industries deviates by more than 20 percent, but these cases are rare. As examples, Figures 5.7 and 5.15 show that the model does not replicate the non-metals and transportation sections for the period 1977-1979, nor does the model capture the cyclical down time in consumer goods in 1980-1982 (Figure 5.12). But with these exceptions, ERDYM does quite well in reproducing the industry output over the historical period 1972-1982.

5.2 ALTERNATIVE POLICY SIMULATIONS

Having described the baseline growth trajectory of the economy, we now turn to the question of what effect alternative policies have on this trajectory. For example, what difference would it make to the growth path of the model if the monetary authorities choose a different decision rule, say, they put more emphasis on unemloyment. This section illustrates the sensitivity of the model to alternative monetary policy parameters. The first alternative simulation considers a change of the relative weight on employment and inflation in the reactive policy function. Subsequent simulations show the behavior of the model in response to constant growth in unborrowed reserves.

5.2.1 Change in Policy Weights

In the baseline simulation discussed in Section 5.1, the weights on the monetary policy function, explained in more detail in Section 3.4, were as follows: the square deviation from targeted unemployment was given 55 percent of the total weight, while the squared deviation from targeted inflation was weighted 45 percent. In the alternative now considered, the weights are shifted to be equal--both inflation and unemployment are given equal weight. This simulation, compared with the baseline simulation, is reported as Table 5.2.

The first page of Table 5.2 shows three of the critical variables from both simulations and the differences between them. As expected, when the monetary authorities put more weight on the inflation target and allow more unemployment, real GNP is lower, unemployment is higher, and inflation is reduced.

Since this does not really represent a major shift in policy, the differences are not large for these three variables. Unemployment is, at its maximum, only about half a percent higher than in the base case. The difference in inflation rates is somewhat greater, but never a full percent lower than that in the base case. By the end of the period reported in Table 5.2, this tighter monetary policy yields a real GNP that is $14 billion lower than the base simulation.

The second page of Table 5.2 reports three additional variables that give an indication of how the shift in policy weights is translated into action. The prime interest rate, BINTR, although usually lower in the alternative simulation, can be lower because the monetary authorities react more quickly to inflationary pressures. The pattern of interest rates demonstrates this quite clearly. Although the movements are very similar, in the alternative case BINTR rises more rapidly and drops more quickly, thus responding more forcefully to inflation before the cumulative effect builds. The monetary policy indicator, MPOL is usually tighter in the alternative than in the base case, and when policy is loose, the alternative case is usually looser. The final variable reported on this page, real producers' durable equipment purchases, responds with sensitivity to changes in the interest rate. Since a more rapid policy allows generally lower interest rates, the alternative case shows a generally higher level of investment in equipment.

5.2.2 Constant Growth of Monetary Base

In this section the reactive monetary policy rule is switched off, and nonborrowed reserves are specified to grow at fixed rates of growth. Our tests with the model revealed that growth rates of reserves must be chosen to be reasonably consistent with the initial growth rates of nominal income and with the wage function of the model. Table 5.3 compares six key variables for two simulations: 1) a base case for which nonborrowed reserves grow at a 7.5 percent annual rate and 2) an alternative in which the growth rate is raised to 8 percent. A comparison of real GNP between the two scenarios shows that, in the long run, the rate of money growth does not appreciably affect the overall level of economic activity. Nominal income is influenced by the rate of money growth; by 1995 the current dollar GNP in the 8 percent case is some 8.6 percent higher than in the base case. This percentage difference is not far from the difference in nonborrowed reserves in 1995, 11 percent.

The cyclical pattern of differences for PDE reflects what one could expect from an economy reacting against alternative levels of reserves growing at fixed rates. In the 8 percent case, interest rates first decline relative to the regime with slower reserve growth. This stimulates investment activity, which in turn lowers the unemployment rate (shown as UnRATE) and pushes up the rate of inflation. The higher nominal income generated by the higher wage and prices then drives up the demand for transactions balances. The dynamics within the model cause the system to slightly overshoot; the increased money demand by 1977 causes interest rates in the 8 percent case to exceed those in the base case. Although this reduces investment demand and pushes up unemployment, the long lags involved cause the inflation rate to remain above the base case until 1985. For the remainder of the 1980s through 1995, another cycle is generated in which the interest rates in the 8 percent case again fall below the base case.

These simulations show that the model can display results reasonably consistent with classical theory, if the alternatvie assumptions regarding money growth are chosen to yield simulations in which the financial and real sectors remain in near equilibrium. Note that the influence of money in the long run price level does not stem from any sort of quantity theory of money. Rather, it stems from more standard economic structure in which the unemployment rate, average over the course of the business cycles, settles at a point that is constant with the prevailing rate of growth in the money supply.

6.0 ATTACK SCENARIOS AND POLICY TESTING

This chapter shows the sensitivity of the revised model to a number of attack scenarios and recovery policies. As discussed in Chapter 2, there is a variety of available policy levers within ERDYM that can be engaged in order to stimulate economic recovery after attack. However, the focus of this chapter will be on the sensitivity with respect to various monetary policy parameters. In addition, the revised model will also be tested to determine if the general conclusions (derived from the original 1980 specification) still hold with regard to the magnitude of the attack scenarios and the importance of the psychological effects. Before turning to the results of the attack simulations, Section 6.1 provides a general discussion of how an attack is represented within ERDYM.

6.1 REPRESENTATION OF DAMAGE

ERDYM employs two mechanisms to represent damage from a nuclear attack or other major emergencies: 1) a sudden reduction of stock variables, 2) a sudden transfer of stocks into a different condition. The fundamental "attack" inputs are physical and "psychological" damage, not megatons of bombs. Any translation of specific weapons "laydowns" into damage estimates must be made outside the model.

6.1.1 Reduction of Stock Variables

The primary means of specifying damage within ERDYM is the immediate reduction of stock variables at a user-specified time period. The equation for each key stock variable contains a special, depleting flow whose value is normally zero. When an attack occurs, this flow is then increased sufficiently to reduce the level of the stock by a specified fraction. The exact magnitude of the flow is determined through what Pugh-Roberts terms a "zap" function. Through the zap function, the destruction of various amounts of population, capital goods, buildings, inventories, and balance sheet variables can be effected in the model. In addition to these tangible items, the levels of various expectation variables--perceived commodity demands, expected standards of living, and so forth--can also be reduced by the same mechanism.

6.1.2 Transfer of Stocks

The transfer of stocks into special categories is another effect of a major attack. In the demographic sector, some fraction of each population group may be specified to be injured and is shifted into a "sick" category. The fraction of those who recover depends on other variables in the model such as the amount of food, exposure to winter weather, and the availability of medical care.

For capital equipment, two special categories that can be activated in the event of an attack are specified in the model. The first category is labeled "rubble," which represents a physical burden to be removed and also a psychological burden--in the sense that it serves as a constant reminder of the drastic change in lifestyle that must now be endured. A second kind of transfer allows the model to realistically represent the damage to key links in an interconnected system. This is accomplished by transferring a portion of the capital stock into a "disconnected" category. Such equipment can make no contribution to current production, as other complementary equipment has been destroyed. Destruction of a portion of electrical transmission lines would, for example, result in the transfer of generation equipment to this category. In the model, the implementation of this feature requires that for each unit of capital destroyed the user specifies a quantity to be transferred into the disconnected category. Subsequent investment after the attack is directed first to rebuilding destroyed bottlenecks; this investment activity then has disproportionate effects on productive capacity as capital is tranferred from the "disconnected" to an operational status.

6.2 ATTACK SCENARIOS

The discussion of attack scenario is divided into two sections. In the first, several scenarios are run to show the recovery response to the magnitude of destruction. In the following section, the level of the attack is held constant, and several types of government policies are examined as to their impact on recovery.

6.2.1 Effect of Attack Magnitudes

The attacks considered in this section are all balanced, in the sense that equal fractions of all stock variable are all suddenly destroyed. Such variables include population, equipment, buildings, inventories, consumer durables, crops, and financial assets and liabilities. One element of this scenario is not "balanced," however. Foreign trade is assumed to be interrupted for the first six years after the attack and then gradually phased in so that complete trade availability is attained a decade after the attack.

Figure 6.1 shows the growth path of real GNP immediately before and following an attack assumed to occur in the first period of 1984. As the figure shows, GNP resumes growth at basically the same rate as before the attack.

As Pugh-Roberts pointed out, this immediate resurgence of growth after the attack is not unexpected since a standard economic model cannot distinguish between a small, healthier economy and a formerly larger, but now damaged economy of the same size. In an actual attack, however, there is some memory of the attack in the form of bodies of the dead, the rubble of destroyed buildings, and the changed attitudes of the survivors. This memory may have its own impact on the economy by influencing work and saving habits.

In Figure 6.2, the path of real GNP is compared for simulation involving 30 and 50 percent attacks, in addition to the 10 percent destruction scenario considered above. For the attacks with greater destruction, RGNP actually declines for some years following the attack before sustained recovery begins. The simulations also suggest threshold or nonlinear relationship. The ultimate decline in GNP from the 30 percent scenario is much closer to the 50 percent than to the 10 percent case.

The downward spiral in these 30 and 50 percent cases can be traced to the psychological reaction of the population to the more massive levels of destruction. With tangible evidence of the horror of the attack all around them, the population loses confidence in the future. This decline of confidence is manifested in many workers leaving the labor force, and in declines in work effort by those that do remain employed. Further reduction in public confidence then occurs in response to the drop in output caused by these

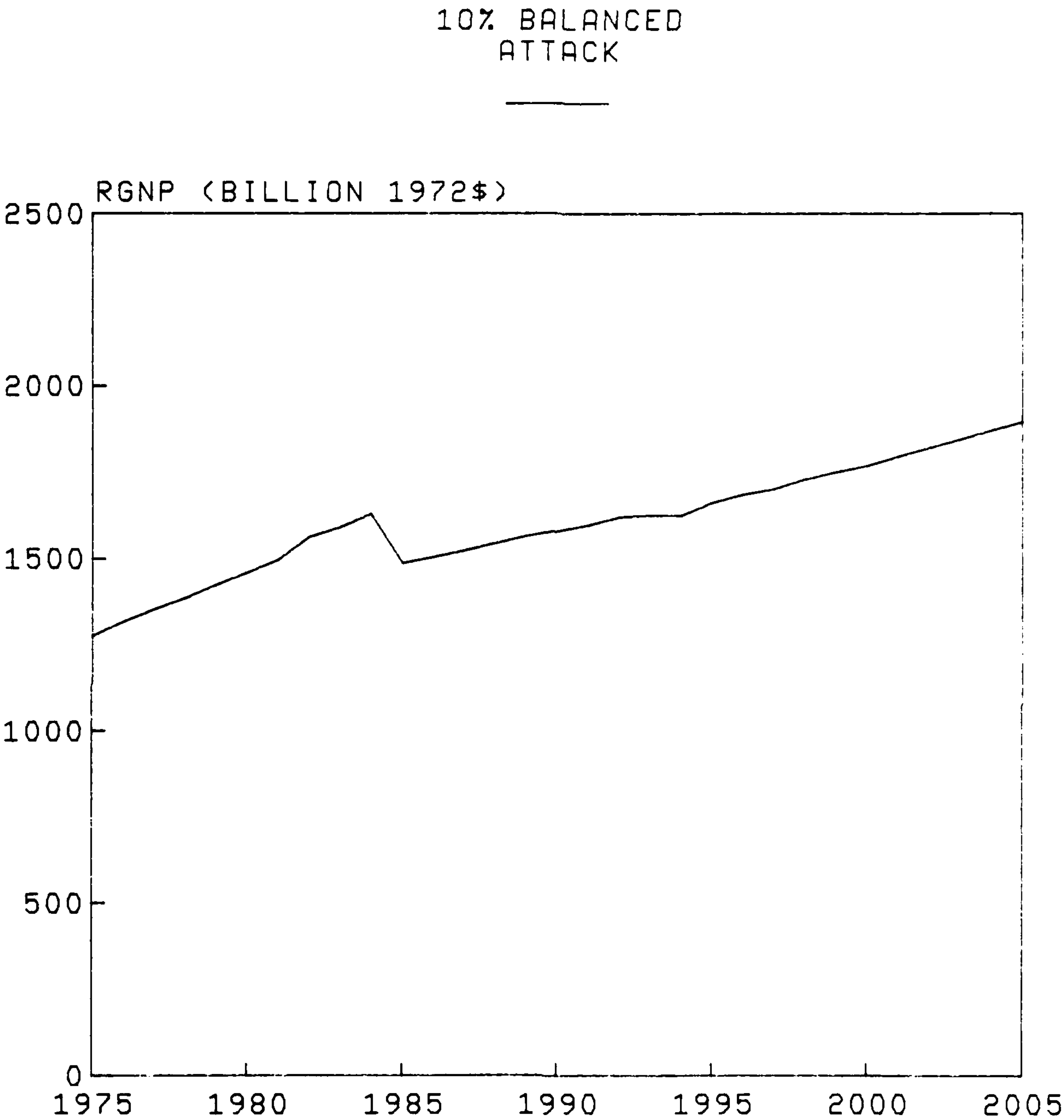


FIGURE 6.1. Simulated Real GNP Under 10% Balanced Attack

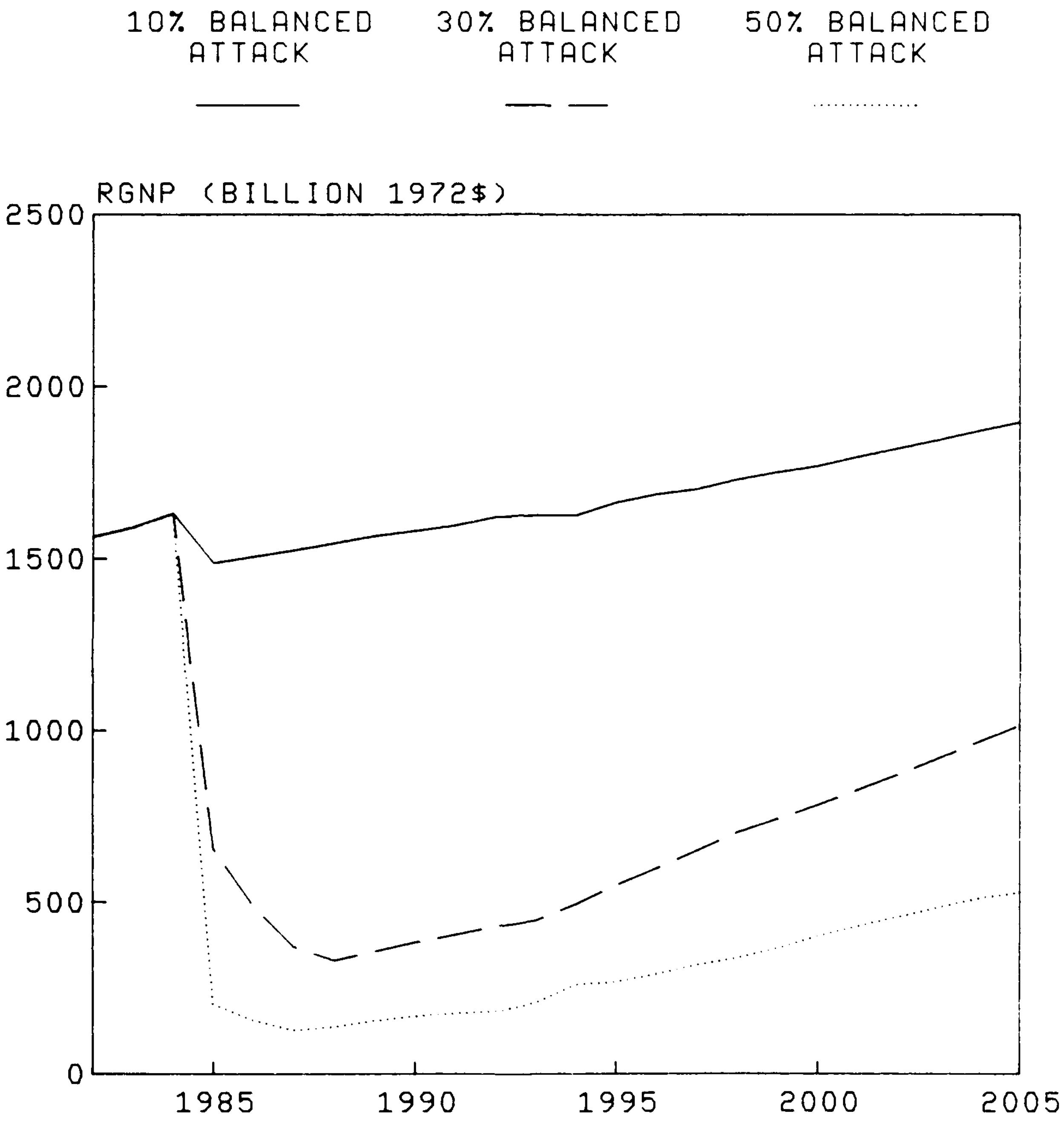


FIGURE 6.2. Simulated Real GNP Under 10%, 30% and 50% Balanced Attack

initial responses by workers. Thus, a downward spiral in national economic activity is generated as public confidence, worker attitudes, and losses in production all reinforce one another.

The behavior of real GNP for the 50 percent case differs from that generated by Pugh-Roberts in the 1981 final report, (reproduced here as Figure 6.3). First, we have incorporated "balance sheet reform" in all scenarios--corporate debt is reduced proportionally to the losses in physical and capital assets. Second, the maximum percentage loss in worker productivity from the decline in public confidence is limited to 25 percent, which we believe is more reasonable than the figure of 50 percent chosen by Pugh-Roberts. This latter assumption results in a minumum level of real GNP that is higher than the Pugh-Roberts level. (In their 50 percent case, real GNP bottoms out at some 90 percent below the pre-attack level.) The lack of balance sheet reform is really what precludes any sustained recovery in their simulation. If this were clearly the limiting factor preventing recovery, it is unrealistic to believe government would stand by for several decades without instituting some steps toward reform.

In the present version of ERDYM, the psychological behavioral "links" work only through worker productivity and labor force participation. In an effort to reveal the separate channels of influence of these responses, three additional simulations were performed with a constant 30 percent balanced attack scenario. In the first of these simulations, it is assumed that worker productivity does not fall in response to the public confidence index. The second simulation reinstates the productivity response, but turns off the influence of public confidence on labor force. In the final simulation both of these influences are removed; thus the model essentially is a pure economic model only. The trajectories of real GNP in the three simulations, along with the standard case with both psychological effects, are shown in Figure 6.4.

The simulation shows clearly that the <u>interaction</u> of these two responses is primarily responsible for the magnitude decline in real GNP. For each considered separately, the severity of the decline is not nearly as great. The intent of these simulations is to reveal to the potential model user the critical nature of a few key relationships when the psychological sector is activated.

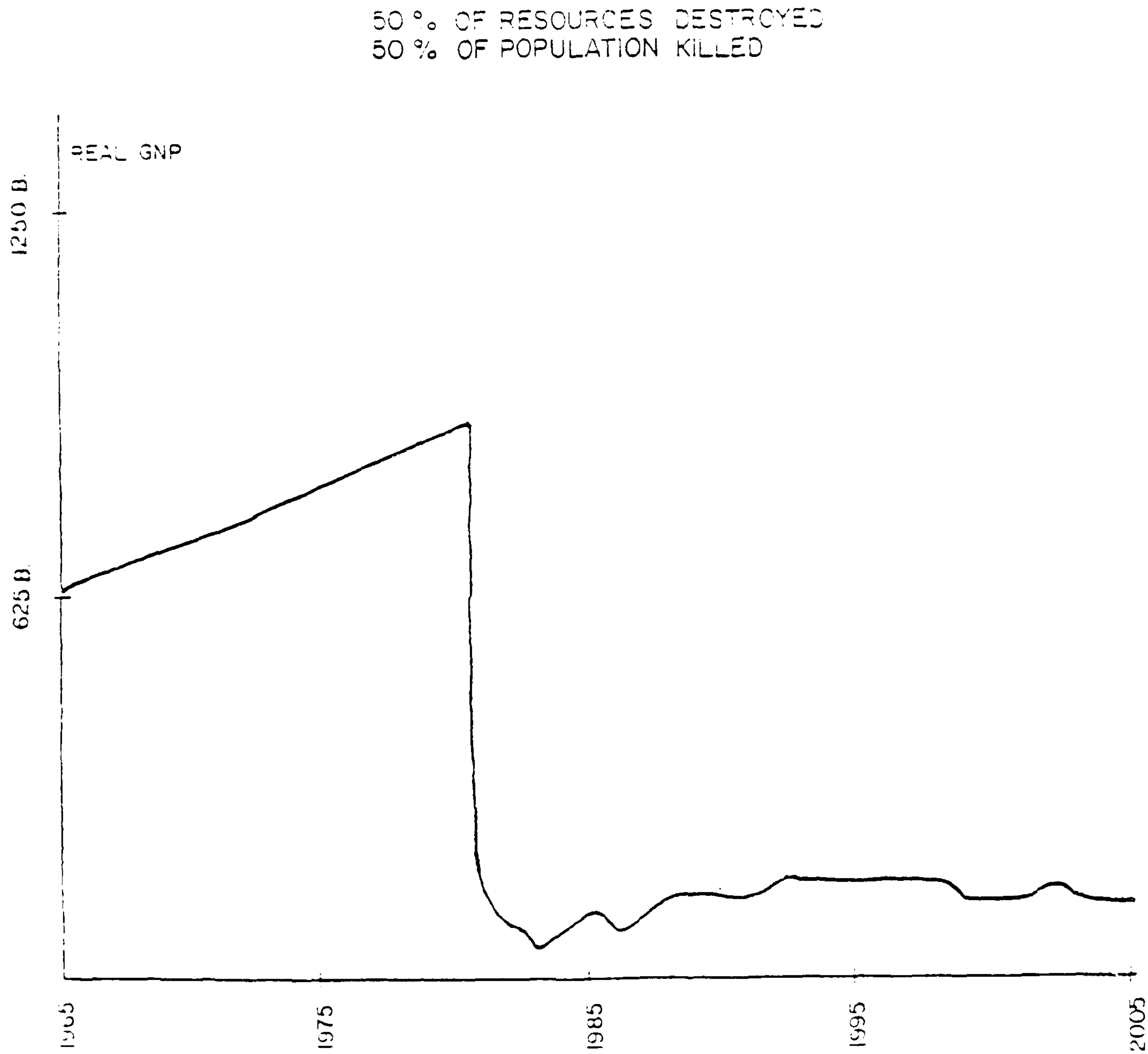


FIGURE 6.3 Effect of 50 Percent Attack Without Balance Sheet Reform (Peterson 1980)

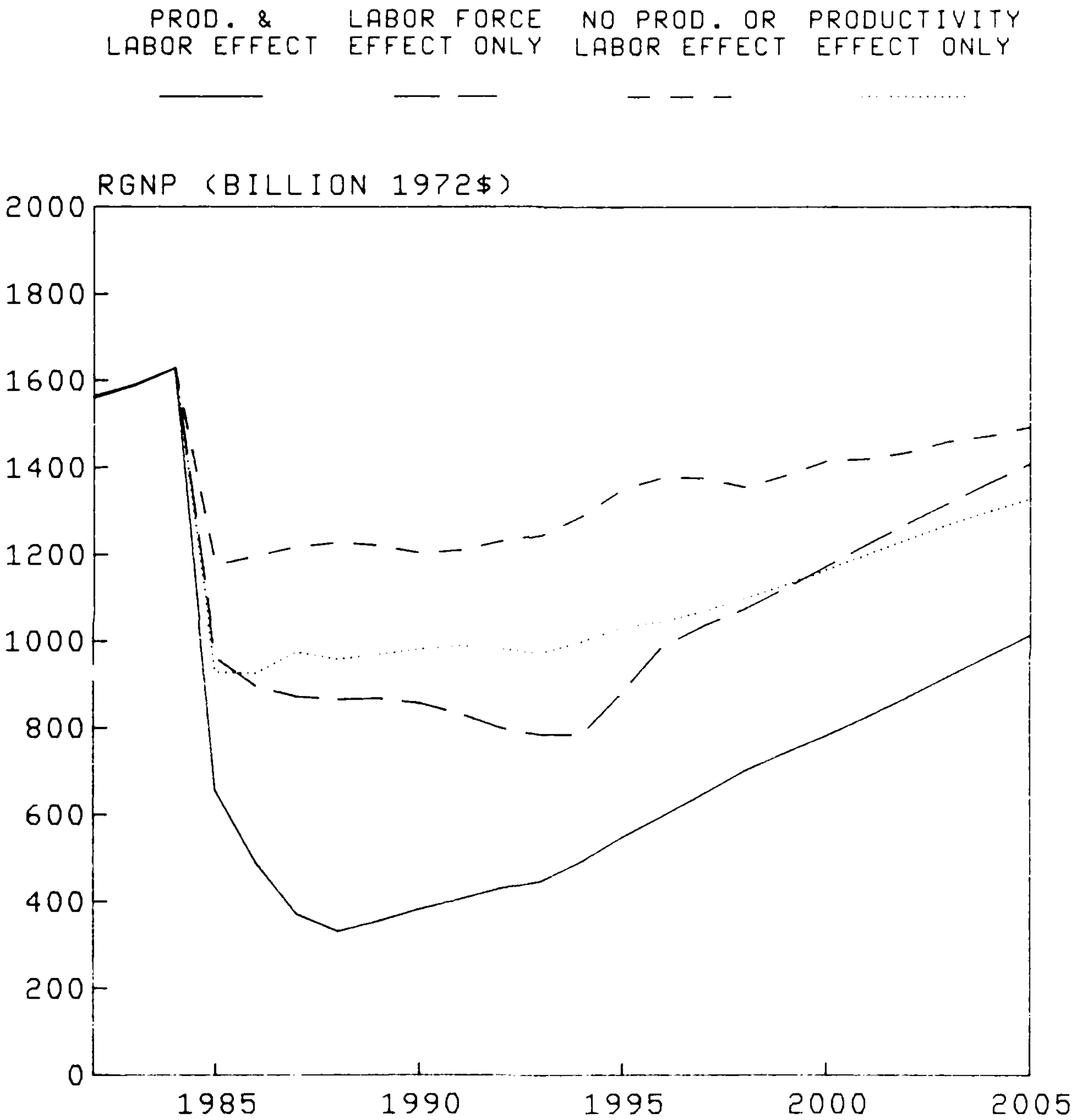


FIGURE 6.4. Simulated Real GNP Under 30 Balanced Attack: Decomposition of Psychological Productivity and Labor Force Effects

6.2.2 Policy Testing

This section concentrates on the impacts that particular monetary policies and levels of interest rates may have on the nature of the recovery process. The first two simulations are for a balanced attack of the type considered in Section 6.1. Further simulations look at an unbalanced attack, in the sense that the destruction of capital is not the same for each sector.

The first pair of simulations compares alternative monetary rules over the first six years after the hypothetical attack. As before, the attack is assumed to occur in early 1984. In this case, the monetary policies are assumed to follow the same policy rules as for the baseline simulation described in Chapter 5. In the alternative ("relaxed") case, it is assumed that a higher degree of inflation and a lower level of unemployment will be tolerated until 1990. After 1990, it is assumed that the policy rule will revert to the same as in the base case. In terms of the targets of the monetary rule we have:

Targets for	Growth Rate	Unemployment Rate	Inflation Rate
Standard Case	2.5	6	3
Relaxed Case	10.0	4	20

Figure 6.5 compares the path of real GNP under the two scenarios. The relaxed case does show a higher level of real GNP through most of the post-attack period, although the series are gradually converging. The relaxed case also shows more cyclical variation than that under the standard rule.

However, considering real GNP alone can be misleading as an indicator of the total benefits of the relaxed policies. Inflation rates in the relaxed case are generally higher throughout the scenario; by 2005 the price level is more than double than that in the standard policy.

Table 6.1 compares a number of key macroeconomic indicators for both policies at the beginning of each year following the attack. Real GNP is in

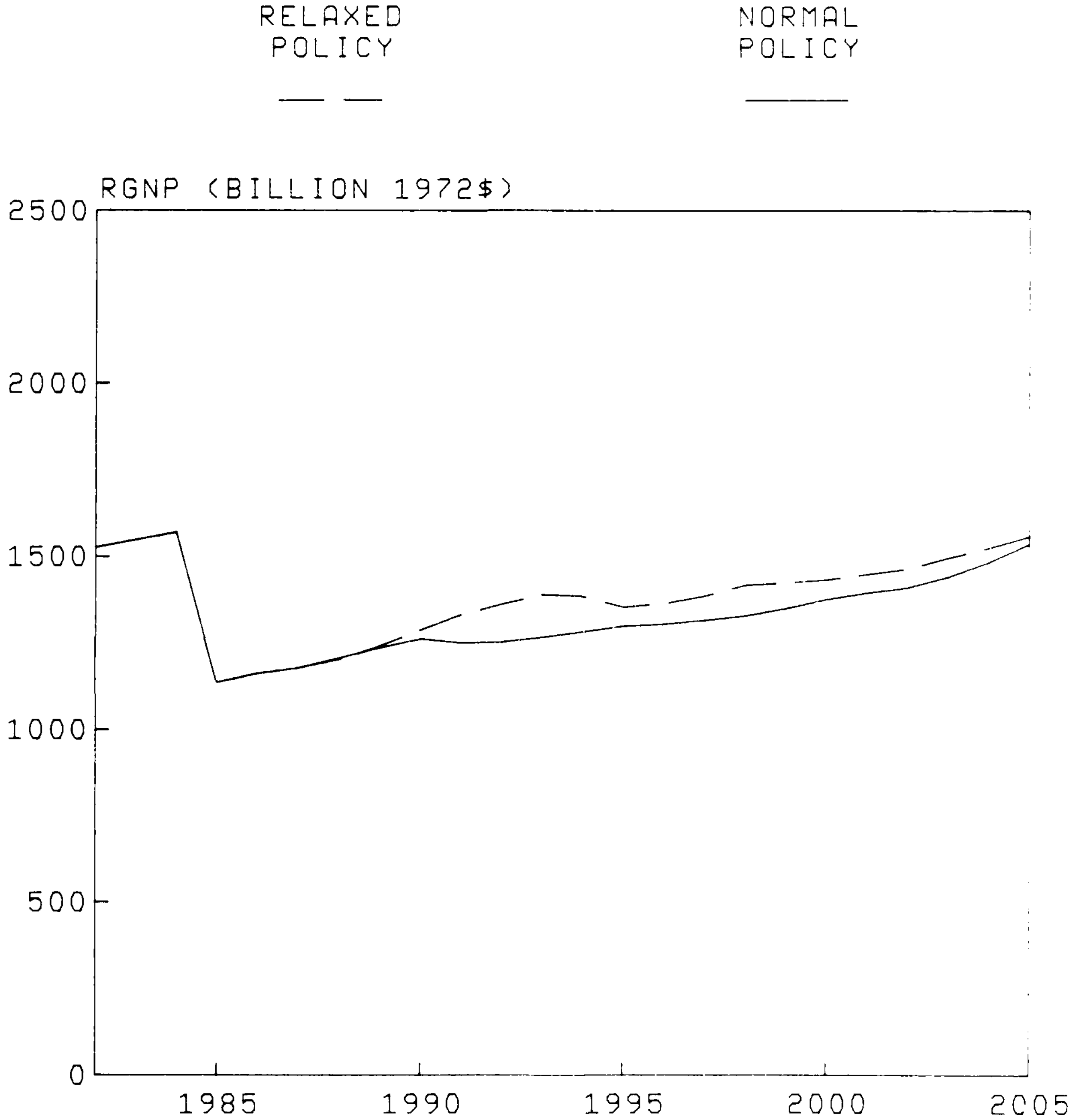


FIGURE 6.5. Simulated Real GNP Under 30% Balanced Attack: Effect of Different Monetary Policies

TABLE 6.1. Comparison of Alternative Policy Targets in the Post-Attack Period (1984-1990)

Base: .06 (UERATE)/.03 (INFR)
Alt: .04 (UERATE)/.20 (INFR)

RGNP REAL GROSS NATIONAL PRODUCT (1972$/YR)
TPDE72 PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)
UERATE UNEMPLOYMENT RATE (FRACTION)

PER	TIME	BAS- RGNP	ALT- RGNP	DIFF	BAS-TPDE72	ALT-TPDE72	DIFF	BAS-UERATE	ALT-UERATE	DIFF
EXPONENT - -)		9 0000	9 0000	9 0000	6 0000	6 0000	6 0000	-3 0000	-3 0000	-3 0000
1	1982 00	1526 700	1526 700	000	78822 000	78819 999	-2 001	65.581	65 581	000
2	1983 00	1549 200	1549 200	000	77477 000	77479 999	2 999	68 984	68 984	000
3	1984 00	-876 100	-876 100	000	78937 000	78939 999	2.999	70 011	70 011	000
4	1985 00	1135 500	1135 500	000	62835 000	62840 000	5 000	65 531	65 531	000
5	1986 00	1161 800	1161 800	000	75014.000	75029.999	15 999	51.294	51 302	008
6	1987 00	1177 300	1177 400	100	77682 000	79810 000	2128.000	38.827	39 529	702
7	1988 00	1205 300	1201 900	-3 400	74623 000	81979 999	7356 999	33 394	28.972	-4 422
8	1989 00	1235 500	1240 200	4 700	68831 000	86649 999	17818 999	38 678	18 151	-20 527
9	1990 00	1260 800	1288 500	27 700	62530 000	91149 999	28619 999	43 404	6 590	-36 814
10	1991 00	1251 100	1332 700	81 600	55823 000	88659 999	32836 999	54 519	6 442	-48 077
11	1992 00	1253 600	1364 100	110 500	51195 000	79060 000	27865 000	68 535	6 616	-61 919
12	1993 00	1268 200	1391 700	123 500	53983 000	65680 000	11697 000	69 551	9 417	-60 134
13	1994 00	1283 900	1385 900	102 000	59983 000	52700 000	-7283 000	72 986	25 041	-47 945
14	1995 00	1300 400	1356 100	55 700	67313 000	45480 000	-21833 000	75 241	46 497	-28 744
15	1996 00	1306 400	1368.000	61 600	72759 000	49820 000	-22939 000	75 868	49 859	-26 009
16	1997 00	1318 400	1388 700	70 300	78941 000	63790 000	-15151 001	80 819	48 010	-32 809
17	1998 00	1331 100	1420 100	89 000	81623 000	72899 999	-8723 001	85 164	47 581	-37 583
18	1999 00	1352 100	1426 900	74 800	85922 000	73039 999	-12882 001	91 369	55 031	-36 338
19	2000 00	1378 800	1435 500	56 700	92954 000	78130 000	-14824 000	92 416	62 076	-30 340
20	2001 00	1396 300	1450 100	53 800	94766 000	87470 000	-7296 000	90 069	66 985	-23 084
21	2002 00	1411 900	1466 200	54.300	93746 000	92100 000	-1646 000	80 620	68 711	-11 909
22	2003 00	1442 000	1497 100	55 100	93281 000	97359 999	4078 999	72 095	68 662	-3 433
23	2004 00	1484 300	1525 800	41 500	96244 000	104340 000	8096 000	65 939	62 635	-3 304
24	2005 00	1537 100	1559 700	22 600	99831 000	103399 999	3568 999	58 096	48 074	-10 022

TABLE 6.1. (cont'd)

INFR INFLATION RATE (FRACTION/YEAR)
BINTR BUSINESS INTEREST RATES (FRACTION/YEAR)
MPOL MONETARY POLICY INDICATOR

PER	TIME	BAS- INFR	ALT- INFR	DIFF	BAS- BINTR	ALT- BINTR	DIFF	BAS- MPOL	ALT- MPOL	DIFF
EXPONENT	->	-3 0000	-3 0000	-3 0000	-3 0000	-3 0000	-3 0000	0000	0000	0000
1	1982 00	49 440	49 440	000	88 910	88 910	000	875	875	000
2	1983 00	49 300	49 300	000	92 200	92 200	000	1 045	1.045	000
3	1984 00	49 730	49 730	000	88 050	88 050	000	1 825	4 270	2 445
4	1985 00	85 320	85.320	000	56 550	56 550	000	1 423	3 852	2 429
5	1986 00	129 990	129 910	- 080	43 050	43 050	000	.852	2 709	1 858
6	1987 00	159 080	161 370	2 290	60 440	43 050	-17 390	493	1 974	1 482
7	1988 00	114 770	156 850	42 080	89 680	43 050	-46 630	402	1 477	1 075
8	1989 00	55 820	91 180	35 360	110 210	43 050	-67 160	.717	1 126	409
9	1990 00	56 080	73 510	17 430	118 790	43 050	-75 740	458	058	- 400
10	1991 00	68 930	71 080	2 150	139 890	70 220	-69 670	825	065	- 760
11	1992 00	73 820	65 430	-8 390	134 600	98 570	-36 030	1 166	096	-1 070
12	1993 00	90 040	72 950	-17 090	122 670	130 790	8 120	1 054	095	- 959
13	1994 00	97 640	84 230	-13 410	110 310	159 660	49 350	1 097	218	- 879
14	1995 00	100 210	97 110	-3 100	92 370	156 570	64 200	1 143	646	- 497
15	1996 00	132 780	138 820	6 040	60 260	120 570	60 310	1 235	584	- 651
16	1997 00	206 410	155 640	-50 770	44 510	89 230	44 720	1 315	470	- 845
17	1998 00	188 360	145 850	-42 710	44 510	99 320	54 810	1 463	423	-1 040
18	1999 00	94 110	135 150	41 040	44 510	98 250	53 740	1 608	647	- 961
19	2000 00	-33 900	143 400	177 300	44 510	62 530	18 020	2 023	823	-1 201
20	2001 00	-29 650	168 010	197 660	44 510	44 530	020	2 067	917	-1 150
21	2002 00	33 460	150 010	116 550	44 510	44 530	020	1 684	946	- 738
22	2003 00	37 730	86 300	48 570	44 510	44 530	020	1 218	883	- 335
23	2004 00	32 580	51 560	18 980	44 510	44 530	020	1 020	874	- 146
24	2005 00	35 440	113 050	77 610	44 510	50 550	6 040	661	414	- 247

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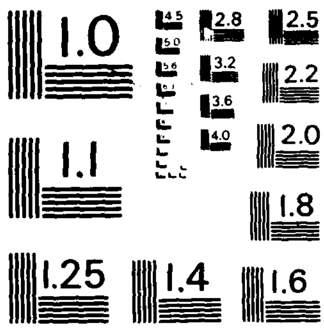

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

fact negative in the first period of 1984; this reflects the large inventory losses accompanying the attack. The reader is reminded that real GNP is expressed at annual rates for the first period (approximately three weeks) of the year. Thus, although real GNP is negative for the first period, the inventory losses of course do not decline at this rate for the remainder of the year and subsequent values of real GNP for the remainder of 1984 are in fact positive.

Even though the policy targets are different up until 1990, equipment investment does not really begin to show much difference until 1988. This is due to the fact that the immediate decline in GNP growth causes even the standard policy to be accommodative in the first few years following the attack. This can be seen in the values of the monetary policy indicator in the second panel of Table 6.1. The values of MPOL are greater than one until 1986. By 1987, the greater restrictiveness of the standard policy is reacting to the supply-generated inflation resulting from the absence of import supplies. By 1989, the business interest rate is more than double that of the relaxed policy. Note the considerable lag in the system; although the policy targets take on the same values in 1990, it takes several years before the rise in interest rates begins to cut back down capital goods spending in the relaxed case.

The pattern of inflation rates calls for some explanation. As the difference column shows, the rates are generally higher throughout the entire period in the relaxed policies case. In the early 1990s the difference largely represents the commodity shortages that are extended by the more stimulative policy. The subsequent difference should be viewed on the "inherited" inflation persisting from the period of high economic activity. Unemployment rates are driven to much lower levels in the expansive policy, so much so that we have imposed a maximum 12 percent annual rate of change in wages. This helps to explain the comparable inflation rates that occur in the early years of the 1990s. The inflation rates drop in these years as the commodity supply shortages are eventually alleviated. The sharp rise in inflation rates in 1997 and 1998 occurs as investment activity again grows rapidly. Detailed analysis of the individual sector variables reveals that the inflationary pressures in 1998-2000 are concentrated in the capital goods and construction sectors, as compared to the more widely dispersed shortages in the period immediately following the attack.

These two simulations reveal that monetary policy may have the capacity to propel the economy on a higher growth path following an attack. However, this can only be accomplished by the acceptance of higher rates of inflation. This conclusion would, of course, be altered if other policies such as price-wage controls or more restrictive fiscal policy were undertaken concurrently.

6.2.3 Unbalanced Attack

In the final attack simulations, the model's response to an unbalanced attack is tested. Although many types of imbalances can be devised with the model, the approach here is a simple one. All stock variables are reduced 30 percent, as before, except equipment and building in the energy and transportation sectors. For these sectors, these stocks of capital goods are reduced by 50 percent.

Initial simulations with either of the policy rules in the previous section revealed a serious limitation of the existing model. Because of the destruction of capital stocks in these sectors, workers in these industries are thrown into the ranks of the unemployed. Although the imbalances are eventually corrected through higher rates of investment in energy and transportation, unemployment rates throughout the simulation never decline to less than 10 percent. This occurs even though under a standard monetary rule the interest rates are driven to their floor levels. Even this stimulus is insufficient to raise aggregate demand sufficiently to fully employ the labor force.

These results arise primarily from the absence of a market clearing mechanism in the labor market, which effectively disables the endogenous monetary policy mechanism within the model. In spite of this limitation, some insight can be gained by analyzing the effects of alternative interest rates compared over the post-attack recovery period (see Table 6.2). In the base solution, business interest rates are a constant seven percent from 1985 through 2005. In the alternative solution, these rates are lowered two percentage points to five percent during 1985-89.

TABLE 6.2. Effect of Lower Interest Rates in Post-Attack Period (1984-1989), Unbalanced Attack

Base: Constant 7 percent business rate
Alt: 5 percent business rate, 1985-1989

RGNP REAL GROSS NATIONAL PRODUCT (1972$/YR)
TPDE72 PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)
INFR INFLATION RATE (FRACTION/YEAR)

PER	TIME	BAS- RGNP	ALT- RGNP	DIFF	BAS-TPDE72	ALT-TPDE72	DIFF	BAS- INFR	ALT- INFR	DIFF
EXPONENT - -)		9.0000	9.0000	9.0000	6.0000	6.0000	6.0000	-3.0000	-3.0000	-3.0000
1	1982.00	1526.700	1526.700	.000	78822.000	78822.000	.000	49.440	49.440	.000
2	1983.00	1549.200	1549.200	.000	77477.000	77477.000	.000	49.300	49.300	.000
3	1984.00	-1165.500	-1165.500	.000	78927.000	78927.000	.000	48.270	48.270	.000
4	1985.00	967.300	967.400	.100	55457.000	55488.000	31.000	169.530	171.620	2.090
5	1986.00	878.000	877.400	-.600	59452.000	61406.000	1954.000	338.950	338.920	-.030
6	1987.00	837.300	841.000	3.700	56241.000	60905.000	4664.000	287.310	304.730	17.420
7	1988.00	847.500	853.700	6.200	55775.000	63144.000	7369.000	30.230	52.200	21.970
8	1989.00	893.000	908.500	15.500	56977.000	64855.000	7878.000	-133.400	-109.440	23.960
9	1990.00	944.600	980.800	36.200	56641.000	66035.000	9394.000	-165.500	-162.340	3.160
10	1991.00	970.800	1000.900	30.100	54401.000	61450.000	7049.000	-76.990	-110.870	-33.880
11	1992.00	994.100	1015.700	21.600	54411.000	56243.000	1832.000	-29.240	-44.330	-15.090
12	1993.00	1009.800	1032.100	22.300	54985.000	54633.000	-352.000	-6.750	-12.660	-5.910
13	1994.00	1038.400	1060.900	22.500	57778.000	56621.000	-1157.000	-23.710	-18.890	4.820
14	1995.00	1078.200	1094.900	16.700	59533.000	58424.000	-1109.000	-25.980	-22.650	3.330
15	1996.00	1112.800	1129.000	16.200	62111.000	61019.000	-1092.000	-5.050	-4.420	.630
16	1997.00	1144.600	1158.600	14.000	65341.000	64533.000	-808.000	-.750	.170	.920
17	1998.00	1177.000	1188.500	11.500	68362.000	67734.000	-628.000	-.960	-.520	.440
18	1999.00	1207.300	1218.900	11.600	70808.000	70456.000	-352.000	5.040	7.300	2.260
19	2000.00	1236.800	1246.500	9.700	72695.000	72445.000	-250.000	1.750	3.910	2.160
20	2001.00	1262.900	1271.700	8.800	74302.000	74111.000	-191.000	-2.530	-1.780	.750
21	2002.00	1288.100	1295.500	7.400	75714.000	75550.000	-164.000	-4.650	-4.380	.270
22	2003.00	1312.600	1318.500	5.900	76947.000	76779.000	-168.000	-5.450	-5.030	.420
23	2004.00	1336.100	1341.300	5.200	77988.000	77854.000	-134.000	-4.920	-4.120	.800
24	2005.00	1360.100	1364.400	4.300	79004.000	78892.000	-112.000	-3.800	-3.720	.080

Note first how the attack in this simulation differs from the results in the balanced case, shown in Table 6.1. The cutoff of imports generates several years of inflation in the 15 percent range. In this simulation, the inflation rate is more than double this figure by 1995; petroleum and other energy shortages that are widespread through the economy drive up prices. (By our assumption of fixed interest rates, it is assumed that the monetary authorities are fully accommodating these rises in the price level.) These inflationary pressures eventually subside as capacity is rebuilt. During the period of prevalent energy shortages, total production, as measured by real GNP, falls as initial inventories are exhausted. By contrast, real GNP in the balanced attack generally rises monotonically after the attack.

Under these conditions, we assume that monetary authorities act to push down borrowing rates for business by two percentage points. Although this works to accelerate capacity expansion in the critical petroleum and transportation sectors, this macro policy also has the effect of spurring investment demand in other sectors of the economy as well. Thus, in Table 6.2 total producers' equipment investment is some $2 billion (1972) higher than the base case. The inflation rate is also higher by roughly two percentage points over the 1987-1989 period.

In the effort to achieve sectoral balance, the capital goods industry cannot meet demands in the mid to late 1980s. This is reflected in the fact that, with the additional investment demand, the difference in realized investment is greater than the difference in total GNP from 1986-1989. Thus, the allocation mechanism seems to be shifting some household consumption of durable goods towards producers. When the shortages are alleviated in the 1990s, the non-investment components of GNP grow rapidly, and the lagged effects of the lower interest rates plus the accelerator effects of a growing economy help maintain relatively high investment activity in 1991 and 1992. The relative differences in equipment investment is reversed in the remainder of the scenario, as producers adjust their long-run desired capital-output ratio. By the year 2005 the transitory impact of the policy changes has nearly dissipated and key variables in Table 6.2 show roughly the same values.

The simulation above suggests that any attempt to lower interest rates or any other component influencing the rental costs of capital, such as investment tax credits, must be accompanied by other measures to decrease aggregate demand. One such obvious measure is reducing personal consumption expenditures by raising personal income tax rates. Several tests of such a combined policy were undertaken by imposing five percent and twenty percent surcharge rates on the existing average effective tax rates. These simulations did show the expected result that inflation rates are lower for the coordinated policy compared to the case shown in Table 6.2. However, other elements of the simulation seemed implausible; in particular, real GNP is some $4 to 10 billion higher in this case than in the case with lower interest rates. We are skeptical of the result especially from prior experience in looking at the behavior of the consumption and savings functions within the model. (Recommendations with regard to the existing consumption specification in the model are outlined in Chapter 8.) Nevertheless, the result suggests that an appropriate coordinated fiscal and monetary policy can promote faster capital reconstruction and subsequent re-establishment of sectoral balance within the economy.

The final simulation departs from the general lines of macroeconomic policies considered above. Within the sectoral aggregation of ERDYM, motor vehicles are considered as capital equipment, capable of being employed in any productive capacity. Thus, any decrease in motor vehicle consumption by consumers can be made available to producing sectors. Table 6.3 compares a base case (constant 7 percent business rates, as in Table 6.2) with an alternative in which motor vehicles purchases by households are rationed by 25 percent over the 1984-1989 period.

The sharpest difference between this case and that considered above is that the inflation rate is reduced by roughly five percentage points between 1986 and 1989. Although real GNP still declines, the minimum level under the policy is some $11 billion higher than the base case. Part of the key to this behavior is suggested in the figures for PDE. By the first period of 1985, total PDE is roughly $500 million higher in this case, than under the base case, (as compared to only $31 million in Table 6.2). Early delivery of capital goods obviously seems to play an important role in moderating the subsequent shortages and inflationary pressures. By 1987, total PDE is lower under the alternative case. This result stems from the reallocation of consumer spending

TABLE 6.3. Effect of Consumer Rationing in Post-Attack Period (1984-1989), Unbalanced Attack

Base: Constant 7 percent business interest rate
Alt: 25 percent reduction of household motor vehicle demand, 1984-1989

RGNP REAL GROSS NATIONAL PRODUCT (1972$/YR)
TPDE72 PRODUCERS DURABLE EQUIPMENT (1972$/YEAR)
INFR INFLATION RATE (FRACTION/YEAR)

PER	TIME	BAS- RGNP	ALT- RGNP	DIFF	BAS-TPDE72	ALT-TPDE72	DIFF	BAS- INFR	ALT- INFR	DIFF
EXPONENT - -)		9.0000	9.0000	9.0000	6.0000	6.0000	6.0000	-3.0000	-3.0000	-3.0000
1	1982.00	1526.700	1526.700	000	78822.000	78822.000	000	49.440	49.440	000
2	1983.00	1549.200	1549.200	000	77477.000	77477.000	000	49.300	49.300	000
3	1984.00	-1165.500	-1165.500	000	78927.000	78927.000	000	48.270	48.270	000
4	1985.00	967.300	964.400	-2.900	55457.000	55925.000	468.000	169.530	151.150	-18.380
5	1986.00	878.000	883.000	5.000	59452.000	60222.000	770.000	338.950	280.180	-58.770
6	1987.00	837.300	848.700	11.400	56241.000	55486.000	-755.000	287.310	240.120	-47.190
7	1988.00	847.500	865.800	18.300	55775.000	55659.000	-116.000	30.230	-14.420	-44.650
8	1989.00	893.000	914.300	21.300	56977.000	56301.000	-676.000	-133.400	-137.910	-4.510
9	1990.00	944.600	962.800	18.200	56641.000	56543.000	-98.000	-165.500	-120.060	45.440
10	1991.00	970.800	987.800	17.000	54401.000	55604.000	1203.000	-76.990	-55.060	21.930
11	1992.00	994.100	1009.100	15.000	54411.000	55841.000	1430.000	-29.240	-21.090	8.150
12	1993.00	1009.800	1022.900	13.100	54985.000	56214.000	1229.000	-6.750	-2.740	4.010
13	1994.00	1038.400	1049.700	11.300	57778.000	58698.000	920.000	-23.710	-21.570	2.140
14	1995.00	1078.200	1086.600	8.400	59533.000	60026.000	493.000	-25.980	-24.070	1.910
15	1996.00	1112.800	1119.200	6.400	62111.000	62235.000	124.000	-5.050	-4.310	740
16	1997.00	1144.600	1148.600	4.000	65341.000	65216.000	-125.000	-.750	090	840
17	1998.00	1177.000	1178.600	1.600	68362.000	67939.000	-423.000	-.960	220	1.180
18	1999.00	1207.300	1207.200	-.100	70808.000	70230.000	-578.000	5.040	6.640	1.600
19	2000.00	1236.800	1234.300	-2.500	72695.000	71957.000	-738.000	1.750	2.590	840
20	2001.00	1262.900	1258.300	-4.600	74302.000	73412.000	-890.000	-2.530	-2.200	330
21	2002.00	1288.100	1281.400	-6.700	75714.000	74672.000	-1042.000	-4.650	-4.380	270
22	2003.00	1312.600	1304.100	-8.500	76947.000	75797.000	-1150.000	-5.450	-4.970	480
23	2004.00	1336.100	1326.700	-9.400	77988.000	76827.000	-1161.000	-4.920	-3.680	1.240
24	2005.00	1360.100	1349.000	-11.100	79004.000	77817.000	-1187.000	-3.800	-3.390	410

toward less capital intensive goods. When rationing is removed in 1990, there is a spurt of investment activity for the subsequent several years. The behavior of the difference in the remainder of the scenario has no simple explanation; it rises from the previous history of investment by producers and is perhaps influenced by the replacement cycle of the motor vehicle stock within households.

The message of these simulations is clear. Targeted policies directed at the shortages after an unbalanced attack can be highly effective in promoting faster recovery. Although general fiscal and monetary policy can help to shift resources toward capital investment, more direct approaches such as direct rationing, may be unavoidable in the aftermath of a major attack.

7.0 CONCLUSIONS

In this chapter, some tentative conclusions are put forth about the sensitivity of the U.S. economy to various magnitudes of attack and the types of policies that may be most effective in aiding recovery. Since this study has focused primarily on the development of a monetary sector and revised investment specification, many of the government policy levers available within the model were not explicitly tested. However, our experience using the model does provide some useful insights as to its behavior simulating a post-attack economic environment.

In some aspects, our experience with the model leads to different conclusions from those reached by Pugh-Roberts in the original model report. To highlight these differences, our organization of topics in the remainder of the section follows to some degree that in the 1981 Pugh-Roberts report.

7.1 VULNERABILITY TO DAMAGE

As Pugh-Roberts concluded, the simulations show that the United States economy is highly vulnerable to nuclear attack. The model suggests that the tremendous physical and psychological damage of a severe attack may trigger a downward spiral of economic collapse that may last over a period of years. From the simulation experiments presented in the previous section, it can be seen that the magnitude of the downward spiral is related in a nonlinear fashion to the magnitude of the attack. The simulation runs indicate that an attack may trigger a severe collapse in the range of 20-40 percent of the labor and capital resources of the economy.

However, as we pointed out before, this conclusion is highly dependent upon how sensitive worker productivity and labor force participation are to the general state of "public confidence" of the population. Our experiments show that only through the interaction of these effects, productivity and participation, would severe downward spirals be generated in response to attacks in the range cited above.

The effect of the sheer magnitude of destruction is exacerbated by potential imbalances among the various sectors and resources. Pugh-Roberts concluded that "in many plausible scenarios, recovery never occurs." Presumably, this behavior occurred in tests for which "standard" accounting procedures continued to be followed after an attack and debt loads associated with the now-destroyed physical capital assets were not forgiven (balance sheet reform). As we have argued elsewhere, we consider this assumption to be unrealistic.

In this study, balance sheet reform was assumed in all post-attack simulations. In no case did recovery ever fail to occur under this assumption (with or without the psychological sector activated), although in some cases up to half a decade was required for the economy to reach a sustained growth trajectory.

7.2 DEGREE OF PREPARATION REQUIRED FOR RECOVERY

An implication of the discussion in Section 7.1 is that pre-attack preparation can contribute to economic recovery. The less the damage resulting from a given weapons "laydown," the less the probability of, and the shorter time period over which, a downward spiral might occur. The strategies that prevent damage--shelters construction, hardening of sites, and dispersion of key production facilities--would be obvious priority elements within an overall civil defense policy.

Although Pugh-Roberts argues that "extensive pre-attack preparation would be required for recovery" (underlining added), one should again be reminded that this conclusion rests heavily upon the particular parameters chosen to represent the psychological response of the economy after an attack. It is clear that pre-attack preparation would leave a greater capital stock (for a given level of attack,) from which a recovery could be initiated. What is highly uncertain, however, is to what degree any additional pre-attack preparation would mitigate downward tendencies within the economic system.

7.3 REQUIREMENTS FOR CONTINGENCY PLANS AND DAMAGE ASSESSMENT

As Pugh-Roberts concluded, simulations of the model do suggest that adaptive civil defense policies are required. Clearly, the nature and extent of imbalances resulting from an attack call for different types of policies. Accurate post-attack damage assessment becomes important in this regard as policies must be adapted to respond to the actual conditions of the economy. An important element influencing the effectiveness of any damage assessment system would be the survival of key communication facilities.

7.4 FOREIGN TRADE

The resumption of foreign trade after an attack would serve as an important aid to recovery. The economics of comparative advantage at the international level would be perhaps stronger in the post-attack environment, since critical bottleneck materials and semi-manufactured goods might be imported until such time as domestic capacity could be rebuilt.

However, the Pugh-Roberts conclusion that foreign trade should be a top priority of civil defense planning does not come strictly from the model. In simulations made of recovery with and without trade, GNP is lower 20 years after the attack with trade resumed than without. This counterinitiative result stems largely from the fact that the model does not correctly account for the influence of exchange rates and does not insure that imports can only be paid for out of export earnings. Thus in the model, when trade again becomes available, imports exceed exports (at least over a period of a few years), sometimes to the extent that real GNP is lowered.

7.5 MACROECONOMIC POLICY

Monetary policy, itself, has some limited capacity to influence recovery from attack in the short run by maintaining borrowing rates low enough to encourage capacity expansion. However, in the long run, maintaining interest rates lower than needed to equilibrate savings and investment can only be accomplished by accepting higher rates of inflation. When the monetary authorities finally react to these higher rates of inflation, as political pressures and historical experience suggest that they eventually must (as in post-World War I Germany), the result is sharply higher interest rates and subsequent decline in investment. Thus, the model suggests that stimulative monetary policy by itself will accelerate recovery only at the cost of higher inflation and greater cyclical instability.

The simulations do not support the Pugh-Roberts contention that expanding the money supply can actually work to reduce inflation by helping to alleviate bottlenecks. This finding springs from their assumption that balance sheet reform does not occur, an assumption we believe to be unrealistic. Even so, the work here suggests that any overall program that focuses just on stimulating investment demand has repercussions for increasing the general price level, as prices of capital goods are bid up. Second, it seems that many of the equilibrating mechanisms one might expect are not working in the Pugh-Roberts scenarios. Our simulations with an unbalanced attack scenario suggest that liberalization of credit or giving outright subsidies to the energy sector would not increase investment requests by this sector of industry. This is simply because the high levels of internal cash flow resulting from high prices are more than sufficient to finance investment demand. The problem is not a lack of funds, but rather real constraints on the supply of capital goods. Thus, a more targeted policy, such as direct rationing of consumer goods that directly compete for productive factors in the capital goods sector, would be expected to be a more effective policy, a result that is suggested by the simulations in the previous section.

8.0 RECOMMENDATIONS

The major criticism of ERDYM at the initiation of this research was that part of the structure of the model was inconsistent with economic theory. This project has been undertaken with the aim of correcting some of these problems--specifically in the monetary sector, in the investment sector, and peripherally as needed for the model to perform reasonably. But experience in simulating the model suggests that much work remains. The remainder of this chapter will highlight some of the problems we have uncovered in the course of this project and will suggest avenues that might be pursued to improve the performance of the model.

8.1 CONSUMPTION

Although it has been necessary to modify the consumption sector somewhat in order that the model perform reasonably, this sector remains a major weakness of the model. In its current manifestation, "available funds"--consisting of current income, new consumer debt, and savings used--determines the level of total desired expenditure, with final demand decisions made on the basis of predetermined priorities that are parameters of the model. There is no explicit consideration of the choice between income and leisure, nor do relative prices affect the quantity demanded of goods. A simpler and more economic representation of the household sector would argue that a choice is made between consumption and savings, and that once the level of expenditure is determined, the choice among goods is made on the basis, primarily, of relative prices. If ERDYM were organized along these lines, a number of problems would disappear. More realistic values of savings flows would be available to influence the financial sector, final demand for goods would respond more realistically to shortages that affect consumer prices, and some of the problems of the labor sector would be mitigated. The consumer sector, then, has high priority for improvement.

8.2 LABOR SECTOR

Another area in need of improvement is the labor sector. In addition to the labor-leisure choice mentioned above, the demand for labor does not currently depend on the real wage. Hence, the sector is constructed in a way that does not allow for equilibration on the basis of excess demand or excess supply. And there are other parts of the labor sector that could benefit from some modification. The tracking of age cohorts and different participants in the labor supply has some merit in evaluating the consequences of attack when much of the population is injured, but not killed outright. But this complication burdens understanding of labor force participation under normal conditions, and gives rise to counter-intuitive behavior. These factors suggest that the labor sector is another candidate for modifications in the event that ERDYM is to be further improved.

8.3 FOREIGN TRADE

A reasonable representation of the foreign trade sector of a macroeconomic model would have the trade weighted value of exchange rates adjust to the trade deficit over time. If a country continues to run a trade deficit, there are two effects--one internal, one external. On the domestic front, the current account deficit serves as a leakage from available savings, and gives rise to higher interest rates, lower output, and increasd monetary flows from abroad--all tending to correct the imbalance. Externally, these altered flows bring pressure to bear on exchange rates. Again, in ERDYM we find this equilibrating mechanism lacking. Since exchange rates, to the extent that they exist, do not adjust to changes in the balance of trade, domestic shortages encourage large influxes of imports with no corresponding revenue-generating exports (which are essentially exogenous to the model). In times of national emergencies that give rise to major production shortfalls, imports can exceed the product generated domestically. National income and product accounting can thus indicate an abrupt drop in GNP. In spite of our limited attempt to remedy this problem, about the only satisfactory way to simulate the model for post-attack recovery is to disenable the trade sector. So again, the foreign trade sector is a candidate for modification.

8.4 FINANCIAL FLOWS

All the preceeding recommendations have implications for financial flows that would need to be integrated into any restructuring of ERDYM. This could be accomplished with some facility if each of the sectors were specified to adhere to balance sheet identities. Then the financial sector could be modified to rely on other sector financial flows, without having to construct these flows from wholecloth. If other sectors were appropriately handled, then the financial sector could concentrate on behavior of monetary and fiscal agents, rather than on the activity in other sectors. This recommendation, then, is one that suggests an aproach to modification of ERDYM, rather than a suggestion for specific change.

8.5 GENERAL

The literature of system dynamics puts considerable emphasis on initializing a model at values that approximate an equilibrium; in the case of a macroeconomic model, this has a number of implications. Our efforts have focused on initializing the model to 1972 National Income and Product Account data--prices, output, income flows, employment, etc. We have not devoted as much effort to assuring that the financial flows of the business sector were in balance as we might have wanted to, nor to establishing equilibrium in other sectors. Assuring a reasonably balanced initialization to a complex model is a task of great magnitude. One recommendation is that, if additional modification to ERDYM is undertaken, sufficient resources be devoted, after modifications are complete, for repeated simulations of the model in an effort to initialize it in reasonable balance. Despite all the software enhancements that this project has undertaken and completed, repeated simulations with minor changes involves considerable effort.

A possible strategy for additional work should take into account the problems to which ERDYM gives rise. A simpler model--with less industry detail, with less psychological detail, with less population and labor force detail, etc., programmed in a more generally available language--might be an economical approach to the development of an economic recovery model that was calibrated to historical experience and gave some confidence of responding to major disruptions reasonably. Such an alternative approach would be much more amenable to fitting to a microcomputer, thus making the model more generally available for planning exercises.

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APPENDIX A

DESCRIPTION OF SELECTED DATA SOURCES

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This appendix describes the data sources and estimation procedures used to initialize many of the key, primarily industry-related, variables in ERDYM. Section A.1 describes how the 1972 Commerce Department input-output table was used to derive key industry variables related to the production relationships and final demands. Section A.2 discusses the development of employment and wage variables by sector. A.3 explains how effective corporate tax rates and dividend payout rates, and other business financial variables were estimated by industry. Initialization of variables associated with investment and capital stocks is treated in Section A.4. Section A.5 describes the revised specifications for transfer payments.

Many of the variables within the model are initialized with data taken directly from published sources. These variables, as in the original model, are documented internally within the DYNAMO code and are not included here.

A.1 VARIABLES DERIVED FROM 1972 INPUT-OUTPUT TABLE

A.1.1 Input-Output Coefficients

Input-output coefficients at the 11-sector ERDYM sector level were developed from FEMA's 257-sector FIOS (FEMA Input-Output System) table for 1972. The FIOS table is a straightforward aggregation of the official 496-sector Commerce Department table for 1972.

Using an aggregation program developed by FEMA staff member Lawrence Salkin, the FIOS "Use" table was aggregated to the 11-sector ERDYM classification, with additional rows and columns to account for final demand and other miscellaneous components. From this aggregated table, base-year values were computed for production (P1972), import fraction (FDIMI), export fraction (IDEXP), and government purchases of goods and services (IOG).

An aggregation was also performed of the FIOS "Make" table, which shows the fraction of each product made in each sectoral category of establishments. Using this matrix and the MAPS software available on the FEMA UNIVAC computer, a "purified" transaction matrix was computed using the assumption that each product is made by the same process regardless of the type of establishment that makes it. The procedure used involved multiplying each row of the "Use" matrix by the inverse of the "Make" matrix. (See Clopper Almon, et al. 1985: Interindustry Forecasts of the American Economy, pp. 151-152, for a detailed discussion of the procedure.) At the high level of aggregation of the ERDYM model, the difference between the coefficients based on the original "Use" or purified matrix are small. However, the procedure does help to clarify the internal accounting within the model and eliminates the need for separate recognition of product and establishment output.

A.1.2 Production (P1972)

To start the solution process for the model, initial values for production are required. These values were taken from the aggregation of the FIOS "Use" table as described in the previous section. The values for the 11 ERDYM sectors, in millions of 1972 dollars, are shown in Table A.1.

A.1.3 Government Purchases of Goods and Services (IOG)

Government purchases of goods and services in ERDYM depend upon the number of government employees. The initial ratio of goods purchased to employment is computed internally within the model, and this base-year value of government purchases is entered directly into the model (via table IOG). The 1972 values for government purchases from each of the 11 ERDYM sectors are also shown in Table A.1.

A.1.4 Imports (FDIMI)

Initialization of the model for imports requires import fractions as a percentage of total product demand (defined as domestic production + imports). These fractions for 1972 were derived from the aggregated FIOS "Use" table, described in Section A.2.1. The computed values used in the model to define the FDIMI table are also shown in Table A.1.

A.1.5 Exports (IOEXP)

Exports are projected on the basis of fractions of total product demand (domestic production + imports). These fractions for 1972 were derived from

TABLE A.1. Data from 1972 Input-Output Table Used for Production and Final Demand Initialization (Millions of Dollars)

ERDYM	Sector	Production	Government (IOG)	Imports (FDIMI)		Exports (IOEXP)	
1	Metals	62,235	232	7,121	.1033	1,749	.0252
2	Non-metals	23,927	134	1,150	.0459	550	.0219
3	Energy	111,216	4,675	6,051	.0516	1,367	.00012
4	Non-fuel Consumables	184,492	12,158	10,160	.0522	7,758	.0399
5	Capital	246,858	18,575	18,082	.0683	27,228	.0801
6	Construction	165,997	39,900	0	0	16	0
7	Consumer Goods	88,031	6,848	7,863	.0820	3,031	.0316
8	Agriculture	201,890	1,358	6,899	.0330	7,861	.0376
9	Medical	55,305	7,619	0	0	0	0
10	Transportation	76,617	4,573	1,152	.0148	5,213	.067
11	Services	747,717	20,103	0	0	8,253	.0110

the 1972 aggregated FIOS "Use" table, described above. The computed values used in the model for IOEXP are, again, shown in Table A.1.

A.1.6 Distribution of Value Added

Value-added in the 11-sector purified table was computed by subtracting the sum of intermediate inputs from total production. A distribution of the value-added for the base period into payments to primary factors (wages and profit income) and indirect business taxes is required to properly initialize the model for the competition of prices and incomes. Annual data on major income components at the two-digit SIC level were used to estimate such a distribution. This set of data, termed Components of Gross Product Originating, is updated annually by the Bureau of Economic Analysis (BEA) within the Department of Commerce.

The first step in this procedure was to aggregate from the 64 industry series provided by BEA to the 11-sector ERDYM classification. Each two-digit sector within the BEA data set was assigned to the most appropriate ERDYM sector. The sum of the various components was then compared to the total value-added figure derived from the aggregated FIOS table. Since the correspondence between the total value-added from these two sources was reasonably good, the BEA data were then used to simply allocate the value added from the aggregated table on a prorata basis. The results of this procedure are shown in Table A.2. The part of value-added that is wages and wage supplements is described in Section A.2; these and indirect business taxes (shown as column 5 of Table A.2) are used to initialize related variables as described below.

A.1.7 Indirect Business Taxes Paid (OTXPD)

Indirect business taxes paid are based on the value-added distribution described in the previous section for 1972. Indirect business taxes is one of the 14 components of Gross Production Originating estimated by the Commerce Department at the 2-digit SIC level. As such, it is a line item in the adjusted value-added table shown in Table A.2. Indirect business taxes consist of a variety of various taxes and fees; the principal is local property taxes. Although not an indirect tax in the strictest sense, federal excise taxes are also included in this category.

TABLE A.2. 1972 Value-Added Components Adjusted for ERDYM*
(Millions of Dollars)

ERDYM	Sectors	Corporate Profits + IVA	Proprietors Income	Net Interest	Capital Consumption Allowance	Indirect Business Taxes	Total Value Added
1	Metals	1,329	-9	816	2,835	1,396	23,512
2	Non-Metals	1,504	147	199	1,468	491	11,943
3	Energy	5,621	422	4,071	9,737	9,116	44,385
4	Non-fuel Consumables	12,129	969	1,535	8,064	3,931	83,954
5	Capital	13,682	392	1,740	8,530	2,767	105,863
6	Construction	2,732	9,711	521	3,913	2,566	
7	Consumer Goods	4,355	395	679	1,242	3,824	34,862
8	Agriculture	2,824	20,683	3,634	74,741	7,874	64,940
9	Medical	486	9,510	203	686	237	34,380
10	Transportation	1,372	1,690	1,489	6,034	2,506	44,120
11	Services	37,630	52,975	32,035	47,301	72,804	518,076

* Excluding wages and salaries, and wage supplements; see Table A.4.

A.2 EMPLOYMENT AND COMPENSATION

A.2.1 Wage Rates by Sector (WAGEI)

Data for average wage rates for 1972 by ERDYM sector were derived from Battelle's FORSYS Model data base. FORSYS wage rates were developed by using wage and salary data from Table 6.5 of the National Income and Product Accounts (NIPA) and employment information from the Bureau of Labor Statistics' Office of Economic Growth. A correspondence was developed to aggregate FORSYS model sectors to the 11-sector ERDYM classification in the private economy. Estimates of total wage bill and employment were then made for the 11 private ERDYM sectors. Wage rates were derived by simply dividing wage bills by employment for each of the 11 sectors. The results are shown in column 2 of Table A.3. The average wage rate for ERDYM sector 12, government, was taken from Table 6.5 of the NIPA.

A.2.2 Employment (BCLI)

Base-year employment by sector is computed to maintain consistency with the estimated value-added breakdown of the 1972 aggregated input-output table. Wage bills were taken from the revised value-added distribution table described in section A.1. Employment for wage and salary workers was then computed by dividing average wage rates (as discussed in the preceeding section) into the wage bills. Values for these variables are shown in columns 1 through 3 of Table A.3.

For four sectors, self-employed workers make up a significant fraction of the total work force. Based on data from Table 6.14 of the NIPA, the total employment in these sectors was increased to include these workers. These estimates are shown in columns 4 and 5 of Table A.3.

A.2.3 Employee Benefit Expense (EMBEX)

Employee benefit expenses are derived from the value-added distribution table used in the computation of total employment described in the previous section. This table provides a measure of wage supplements (benefits +

TABLE A.3. Derivation of 1972 Employment

ERDYM	Sector	Wage Bill I-O Basis (Mill. $)	Wage Rate $/yr.	Employees (thous.)	Self-Employed (thous.)	Total Employment (thous.)
1	Metals	14,217	10,492	1,355		1,355
2	Non-Metals	7,028	9,120	771		771
3	Energy	12,697	11,482	1,106		1,106
4	Non-fuel Consumables	50,082	9,092	5,508		5,508
5	Capital	66,911	10,244	6,531		6,531
6	Construction	50,598	10,023	5,047	600	5,647
7	Consumer Goods	21,519	6,519	3,301		3,031
8	Agriculture	19,749	3,901	5,052	1,800	6,862
9	Medical	20,535	6,664	3,081	250	3,331
10	Transportation	26,842	10,471	2,563		2,563
11	Services	243,240	6,845	35,534	4,000	39,534

employer payroll taxes) consistent with the input-output conventions of the 1972 (aggregated) table. These values are shown in column 1 of Table A.4.

As the first step of deriving employee benefits paid in 1972, estimates were made of employer social security taxes. Table 6.14 of the NIPA provides data on employer contributions for social insurance by 12 broad industry groups. Ratios of these values to total wages and salaries paid were computed and then assigned to the 11 ERDYM sectors. Estimates of total employer payroll taxes were made by multiplying these effective rates by the wage bill derived from the value added distribution table. These values are shown in columns 2 to 4 in Table A.3. Employee benefit expense was computed as simply the difference between total supplements (column 1) and estimated payroll taxes (column 4) and is shown in column 5. As part of the initialization phase of the model, this variable is converted to a per-employee basis by dividing by the initial number of employees.

A.3 BUSINESS FINANCIAL VARIABLES

A.3.1 Balance Sheet Items

The business balance sheet consists of three assets, debt and equities. The general strategy for calculating these balance sheet items was as follows: first, a balance sheet comparable to the one contained in ERDYM was constructed from the financial information contained in the IRS, Statistics of Income, 1972; then ratios were constructed for debt to total liabilities and for the three assets (cash, inventories and book value of capital) to total assets; then a new balance sheet was constructed based on the sectoral balance sheet reported as Table 12 in Goldsmith (1982) for 1975; finally, these figures were adjusted to 1972 totals. There are two notable exceptions to this stategy. Sector debt was calibrated to the National Income and Product Account interest payments given an average sector interest rate (computed from IRS information). Sector equities are initialized by equating them to total assets minus debt. Table A.5 shows the initial values for the major balance sheet items of the business sector.

TABLE A.4. Calculation of 1972 Employee Benefit Expense (Millions of Dollars)

ERDYM	Sector	Wage Supplements	Wages & Salaries	Effective Payroll Tax Rate	Payroll Taxes	Employee Benefits
1	Metals	2,886	14,217	.005	782	2,104
2	Non-Metals	1,068	7,028	.055	387	681
3	Energy	2,562	12,697	.045	571	1,991
4	Non-fuel Consumables	6,775	50,082	.045	2,755	4,218
5	Capital	11,591	66,911	.055	3,680	7,911
6	Construction	5,496	50,598	.059	2,985	2,511
7	Consumer Goods	2,741	21,519	.055	1,184	1,557
8	Agriculture	2,600	19,749	.050	987	1,613
9	Medical	2,471	20,535	.047	965	1,506
10	Transpor-tation	3,910	26,842	.057	1,530	2,380
11	Services	28,859	243,240	.047	11,432	17,427

TABLE A.5. Major Balance Sheet Items by Sector
(Billions of dollars)

ERDYM	Sector	Cash	Inventories	Book Value	Debt
1	Metals	13.90	21.89	35.54	24.4
2	Non-Metals	6.82	6.65	12.07	5.40
3	Energy	47.14	27.12	189.60	104.10
4	Non-Fuel Consumables	53.40	60.64	79.79	42.10
5	Capital	127.98	129.32	58.02	53.40
6	Construction	34.63	0.0	26.09	19.30
7	Consumer Goods	16.84	30.33	10.50	18.90
8	Agriculture	11.05	38.40	84.00	93.20
9	Medical	5.74	0.0	86.70	6.8
10	Transportation	65.24	0.0	87.00	55.20
11	Services	117.80	0.0	290.40	1030.10

A.3.2 Corporate Profit Tax Rate (TR)

Corporate profit tax rates were based on data on corporate profits and corporate taxes paid as published in Tables 6.21 and 6.22 of the National Income and Product Accounts. These data are shown at generally the 2-digit SIC level of detail. The data were aggregated to the ERDYM 11-sector level using the same classification conventions used for the development of wage rates. Tax rates for the model were taken as the average of effective tax rates computed over the period 1972-1979. The values for TR used in the model are shown in Table A.6.

A.3.3 Dividend Payout Rate (DRN)

Dividend payout ratios were based on data on corporate after-tax profits and dividends paid, as published in Tables 6.23 and 6.24 in the National Income and Product Accounts. The same aggregation procedure used for corporate profit tax rates, described above, was applied to dividends.

Since dividends usually lag changes in profits, the long run payout rate was derived on the basis of a simple regression. The following regression was run from 1960-79 for each of the ERDYM sectors:

$$DIV = a\ CPAT + b\ DIV_{t-1}$$

where

DIV = dividends paid

CPAT = corporate after-tax profits

For most sectors, the estimated value of b ranged between .7 and .9, implying a fairly slow adjustment of dividends paid to profit levels. Within this simple Koyck lag specification, the long-run payout ratio is defined as a/(1-b). These generally ranged between .4 and .6. The values for each of the ERDYM sectors are shown in Table A.6.

A.4 CAPITAL STOCKS AND LIFETIMES

Capital stock estimates (equipment and structures) for some 180 manufacturing and nonmanufacturing sectors are maintained by the Bureau of Industrial Economics (BIE), U.S. Department of Commerce. The BIE Capital Stocks Data Base contains estimates of capital stocks in current and constant

TABLE A.6. Corporate Tax Rates and Dividend Payout Ratios

ERDYM	Sector	Effective Tax Rate (TR)	Dividend Payout Ratio (DRN)
1	Metals	.375	.587
2	Non-Metals	.353	.428
3	Energy	.291	.469
4	Non-fuel Consumables	.441	.504
5	Capital	.469	.450
6	Construction	.341	.264
7	Consumer Goods	.462	.447
8	Agriculture	.453	.564
9	Medical	.250	.600
10	Transportation	.368	.600
11	Services	.417	.435

dollars for both equipment and structures. Estimates are available on either a gross stock concept (i.e., not accounting for economic depreciation) or on a net stock basis. For the ERDYM model, the initial values for stock were based on an aggregation of BIE estimates for 1972 constant-dollar net stocks to the 11-sector ERDYM industry classification. The estimates are the 1971 end-of-year values and are shown in column 4 of Table A.7 for equipment and the corresponding columns of Table A.8 for structures.

Lives for equipment and structures were derived from the investment and capital stock series available within the BIE Capital Stocks Data Base. Although BIE does not use an exponential decay function in building up its capital stock series, the implied rate of depreciation changes fairly gradually. The implicit rate of depreciation was derived by first computing 1972 replacement investment (as the difference between gross investment and the change in capital stock) and then dividing this value by the 1972 end-of-year stock. The useful life was finally computed as the reciprocal of the implied depreciation rates.

The data used to derive the average equipment lives to the model are shown in Table A.8. Equipment used in the construction sector has the shortest lifetime, at just over seven years. Lives for equipment in the other sectors generally range between 9 and 13 years.

The data used to derive the average lives for structures are shown in Table A.8. Lives for structures used in manufacturing generally range between 25 and 35 years. For commercial buildings, which generally fall within the service sector, the implied life was nearly 70 years.

A.5 TRANSFER PAYMENTS

Transfer payments in ERDYM remain exogenous, but are now expressed in constant (1972) dollars per beneficiary. Transfer payments are divided into three major categories.

A.5.1 Social Insurance Benefits (Table BPOPT)

The category consists of OASDHI benefits and government employee retirement benefits as published in Table 2.1 of the NIPA. The sum of these items was

TABLE A.7. Equipment Capital Stocks and Lifetimes
(Millions of 1972 dollars except where noted)

ERDM	Sector	Net Inv.	Gross Inv.	Replacement	Stock 1971	Average Life*
1	Metals	-17	1,960	1,977	25,352	12.82
2	Non-Metals	604	1,456	852	8,765	10.3
3	Energy	5,612	10,720	5,108	61,246	12.0
4	Non-fuel Consumables	2,197	6,703	4,506	60,484	13.4
5	Capital	2,642	5,950	3,308	42,710	12.9
6	Construction	654	2,466	1,812	12,901	7.1
7	Consumer Goods	402	1,252	850	7,634	9.0
8	Agriculture	1,671	8,147	6,476	62,501	9.6
9	Medical	2,041	5,078	3,037	28,444	9.4
10	Transportation	2,301	6,476	4,175	80,185	19.2
11	Services	11,013	29,871	18,858	175,369	9.3

*Average life in years.
Source: Figures aggregated or computed from BIE Capital Stocks Data Base.

TABLE A.8. Structures Capital Stocks and Lifetimes
(Millions of 1972 dollars except where noted)

ERDYM	Sector	Net Inv.	Gross Inv.	Replacement	Stock 1971	Average Life*
1	Metals	-34	723	757	22,537	30
2	Non-Metals	113	326	213	7,482	35
3	Energy	6,468	13,484	7,016	195,281	28
4	Non-fuel Consumables	422	1,489	1,067	37,280	35
5	Capital	479	1,413	934	34,016	36
6	Construction	490	675	185	5,738	31
7	Consumer Goods	295	467	172	6,325	37
8	Agriculture	1,142	2,311	1,169	52,884	45
9	Medical	4,449	5,475	1,026	95,330	92
10	Transportation	-881	794	1,675	45,009	27
11	Services	12,881	15,903	3,022	202,263	67

*Average life in years.
Source: Figures aggregated or computed from BIE Capital Stocks Data Base.

deflated to 1972 dollars using the overall GNP deflator, and divided by the population age 65 and older. The values obtained are shown in Table A.9. For the model, the values from 1972 to 1982 are specified in Table A.9. For future years, benefits are assumed to rise more slowly, reaching $5000 per person by 1997.

A.5.2 Public Assistance Payments, Excluding Unemployment Insurance (PBASPT)

This category consists of "other transfer payments" and veterans benefits as published in Table 2.1 of the NIPA. These two series were summed and converted to a real per capita time series using the same procedure as for social insurance benefits. The results are shown in column 2 in Table A.9. In ERDYM, values for 1972, 1977, and 1981, were taken as 170, 195, and 195 (1972) dollars per capita, which approximates the actual time series.

A.5.3 Unemployment Insurance Benefits (UIBEN)

As for the previous two categories of transfer payments, total government unemployment insurance were taken for Table 2.1 of the NIPA. This series was deflated to 1972 dollars and then divided by the unemployed population (Source: Economic Report of the President). The resulting series is shown as column 3 in Table A.9. As the table shows, there is little trend to this series, especially after excluding 1975 and 1976 when extended benefits legislation was in effect. To simplify the specification in ERDYM, real benefits per unemployed worker is assumed to be a constant (UIBEN). For the present version UIBEN is set at 1160 dollars.

TABLE A.9. Government Transfer Payments

	Dollars Per Beneficiary		
	Social Insurance Benefits[a]	Public Assistance and Other[b]	Unemployment Insurance[c]
1972	3014	170	1140
1973	3357	173	947
1974	3514	184	1142
1975	3650	208	1766
1976	3863	212	1611
1977	4000	198	1297
1978	4040	195	1040
1979	4107	195	977
1980	4298	208	1182
1981	4514	202	967
1982	4672	189	1125

(a) 1972 dollars per person age 65 and over
(b) 1972 dollars per capita
(c) 1972 dollars per unemployed person
Sources: Table 2.1, NIPA, and Economic Report of the President.

APPENDIX B

GOVERNMENT POLICY LEVERS

Appendix B

Government Policy Levers

This appendix describes how to implement various policy levers that are available within ERDYM. The policy lever variables and tables are organized by major categories described in section 2.6.

B.1 PRODUCTION PLANNING

The variables in this category consist of tables of priorities for the output of each sector. The values in the table determine which sectors are preferred in receiving key inputs to their production process (including households and government). These priorities come into play only when demand exceeds supply. Figure B.1 reproduces the standard settings currently in ERDYM. For reference, the 14 ERDYM sectors associated with each element in the various tables are:

1. Metals
2. Non-metals
3. Energy products
4. Non-fuel consumable materials
5. Capital goods
6. Building construction
7. Consumer goods
8. Agricultural goods
9. Medical services
10. Transportation
11. Services
12. Government
13. Households
14. Exports

Thus, from Figure B.1, if the user wished to increase the amount of energy received by capital goods producers during an energy shortage, the fifth element in table M1PRN might be changed from .5 to 1.0, as follows:

```
T   M1PRN = .5/.5/1/.5/1/.5/.5/.5/.5/.5/.5/.5/.5/.5
```

```
NOTE   PRIORITIES FOR ALLOCATION OF SCARCE RESOURCES
NOTE   (1=MAXIMUM PRIORITY, 0=MINIMUM)
NOTE
T  D1PRN=1/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR METALS (DIMENSIONLESS)
T  D2PRN=.5/1/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR NON-METALS (DIMENSIONLESS)
T  M1PRN=.5/.5/1/.5/.5/.5/.5/.5/.5/1/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR ENERGY PRODUCTS (DIMENSIONLESS)
T  M2PRN=.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR NONFUEL CONSU MATLS (DIMENSIONLESS)
T  CPRN=.5/.5/.5/.5/1/.5/.5/.5/.5/1/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR CAPITAL STOCK (DIMENSIONLESS)
T  PCPRN=.5/.5/.5/.5/1/.5/.5/.5/.5/1/.5
NOTE   NORMAL SECTOR PRIORITIES FOR PRODUCTION CAPITAL (DIMENSIONLESS)
T  BPRN=.5/.5/.5/.5/.5/1/.5/.5/.5/1/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR BUILDING (DIMENSIONLESS)
T  UPRN=.5/.5/.5/.5/.5/.5/1/.5/.5/.5/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR CONSUMER GOODS (DIMENSIONLESS)
T  AGPRN=.5/.5/.5/.5/.5/.5/.5/1/.5/.5/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR AGRICULTURE (DIMENSIONLESS)
T  TRPRN=.5/.5/1/.5/.5/.5/.5/.5/.5/1/.5/.5/.5/.5
NOTE   NORMAL SECTOR PRIORITIES FOR TRANSPORTATION (DIMENSIONLESS)
T  FDSPRN=.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/1/.5/.5/.5
NOTE  NORMAL SECTOR PRIORITIES FOR FINAL DEMAND SERVICES
NOTE   (DIMENSIONLESS)
T  SPRN=.5/.5/1/.5/.5/.5/.5/.5/.5/1/1
NOTE   NORMAL SECTOR PRIORITIES FOR SERVICES - DISTRIBUTION
NOTE   (DIMENSIONLESS)
T  SMPRN=.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/1
NOTE   NORMAL SECTOR PRIORITIES FOR SERVICES - MAINTENANCE AND REPAIR
NOTE   (DIMENSIONLESS)
T  LRPRN=.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5/.5
NOTE  NORMAL LABOR REQUEST PRIORIITIES (DIMENSIONLESS)
NOTE
NOTE
```

FIGURE B.1. Priorities for Consumption

B.2 RATIONING

Rationing is used within ERDYM to restrict the amount of goods and services consumed by households. The user first must specify the start of each rationing period (up to seven) and the length of each:

T RATIME = 1984/1984/1984/1984/1984/1984/1984

Date of rationing start time

T RATLEN = 0/0/0/0/0/0/0

Rationing length (years)

The actual amount to be rationed is set by constants for individual commodities, which specify the per-capita or per household desired requests. To implement rationing, the user needs to know the approximate values of these variables, before appropriate levels can be chosen. In several cases, the normal per household values are not specified in a single variable; the user must compute the figure by dividing total requests by the number of households. Table B.1 describes the specific rationing constants and the appropriate variables to print to determine household requests without rationing.

B.3 WAGE AND PRICE CONTROLS

A maximum annual fractional change in wages for each sector is specified by constant WGUID:

C WGUID = .10

This setting allows wages to increase no faster than 10 percent per year, in both a normal and recovery economy.

Wages can also be frozen in all sectors, during the recovery period only, by setting constant GWCFPA = 0. The user sets the length for this policy by means of constant GCIMPT (government controls implementation time). Thus, for example, if an attack were specified to occur at the beginning of 1986, we would impose the following changes:

C GCIMPT = 3

C GWCFPA = 0

TABLE B.1. Rationing Variables

Consumption	Constant for Rationing (specifies per capita, per household, or per vehicle requests)	Normal Desired Requests
Consumer durables	DCGRAT	CNGDS/HSHD
Energy products	DHMRAT	HDMSDR/HSHD
Non-durable consumer goods	DNCRAT	DCSPC (1)
Non-fuel consumable materials	DNFRAT	DCSPC (3)
Motor vehicle demand for energy products	DMVRAT	OCPMV
Food	DFDRAT	FDREQ
Transportation	DTRRAT	PHSDTR

Here wages in all sectors would be fixed from 1984 until the first period of 1987.

The effect of supply-demand balance on price can also be altered during the government controls implementation time (set by GCIMPT above). This is accomplished by altering the table function which relates price to the supply-demand balance variable (SDB). This table is currently set at the same values as for the normal economy:

T GESDBT = 2/1.6/1.25/1.1/1.05/1.0/.975/.95/.9/.85/.8

B.4 FINANCIAL INCENTIVES AND GOVERNMENT SUBSIDIES

A number of government policy levers are directed toward businesses in order to stimulate investment during a recovery period. The period during which most of the policies are in effect, termed the government planning period, is controlled by two variables:

C TST=198_ (Start date of government planning period)
C TET=198_ (ending date of government planning period)

The number of values in the tables is variable, depending upon the start and end dates, TST and TET, and another constant TINC. TINC is the time increment for all of the government policies described in the section. Normally, TINC=1 and thus the number of table values is TET-TST+1. If TINC were set at half-year intervals, .5, then the number of values in each of the tables below would be ((TET-TST)/2)+1=11. The examples below assume TINC=1 and a 5-year planning period and should clarify how these values are used within the model.

Government Policy on Depreciation

Table EGPDTT controls a time series of values which are used to scale the normal depreciation tax lives on capital stock. The number of values depends upon the setting of TST, TET, and TINC. For example, assume that we wish to reduce depreciation lives to 80 percent of their normal values over the first two years of the planning (recovery) period (starting in 1985) and then maintain this value for three more years. The appropriate changes would then be:

C TST = 1985

C TET = 1990

C TINC = 1

T EGPDTT = 1.0/.9/.8/.8/.8/.8

Availability of New Debt

The potential new debt to finance capital investment can be augmented through a series of tables, AVDBTT (*, i), where i is the sector number. The normal potential new debt is multiplied by the appropriate table value during the government planning period (defined by TST and TET). Thus, if one wished to double new debt available to the transportation sector during the last three years of the planning period (as defined in the above example), one would have:

T AVDBTT (*, 10) = 1/1/2/2/2/2

Note that the availability will increase linearly over the period 1986.0 through 1987.0, since the first value of the table corresponds to the value for TST.

Tax Credit Policy

Corporate tax rates can be reduced throughout the government planning period (via TST and TET) by means of setting the table GTCPCT. Corporate tax liabilities for all sectors would be lowered by 25 percent in the first three years, and thus gradually return to normal with the following change:

T GTCPCT = .75/.75/.75/.75/.90/1.0

Personal income tax rates can be controlled in the same way via table GTCPIT. The card below would reduce personal tax rates by 10 percent for all years in the planning period.

T GTCPIT = .9/.9/.9/.9/.9/.9

Government Policy on Motor Vehicle Demand by Household

ERDYM assumes that the government can influence household requests for motor vehicles during the government planning period. If this mechanism is employed, requests for motor vehicles normally produced by the model are multiplied by a factor interpolated from table EPPMVT. As an example assume that government wished to reduce household motor vehicle requests by 75 percent in the final three years of the planning period and then relax this policy to 50 percent cutback by the end. Thus, one might change EGPMVT to be:

T EGPMVT = .25/.25/.25/.25/.38/.50

Government Subsidies

In a fashion similar to that used for influencing the availability of new debt, separate tables of the form GSUBT (*, i) are used to specify government subsidies. Subsidies are specified in nominal dollars and are simply added to the sector's total revenue. To help set the appropriate level of subsidy, the user should first perform a run of the model in which variables REV (total revenue) and NIBT (net business income) are printed. Assume, then, that this step has been done and that the user wished to provide a government subsidy to the energy sector at 20 billion a year during the government planning period. Then, the following change would be made:

T GSUBT (*, 3) = 20E9/20E9/20E9/20E9/20E9/20E9

B.5 MONETARY POLICY

As described in Chapter 3, monetary policy can be specified in any of three regimes: 1) exogeneous interest rates, 2) policy targets, and 3) exogenous overall reserve base growth. Figure B.2 shows the overall decision logic that must be followed and the key variables. The top box figure shows the variable, MSWCH which is used to enable or disable the entire monetary sector. If MSWCH is 0, all interest rates are specified exogenously. If MSWCH equals one, then interest rates are determined within the model though movement of net free reserves of the commercial banking system. If the monetary switch is on, the user must further determine the mechanism by which the reserve base is changed by the central bank. If RSWCH is zero, then nonborrowed reserves grow by an amount determined within a table function. If RSWCH is one, a reactive policy is pursued, and reserves are increased or decreased in order to achieve the policy targets specified by the user. The specific variables are discussed in detail below.

Monetary Policy Switch (MSWCH, MSWCHT)

Values of the monetary policy switch can be set independently for a "normal" economy and a "recovery" economy. This is accomplished by means of the table function:

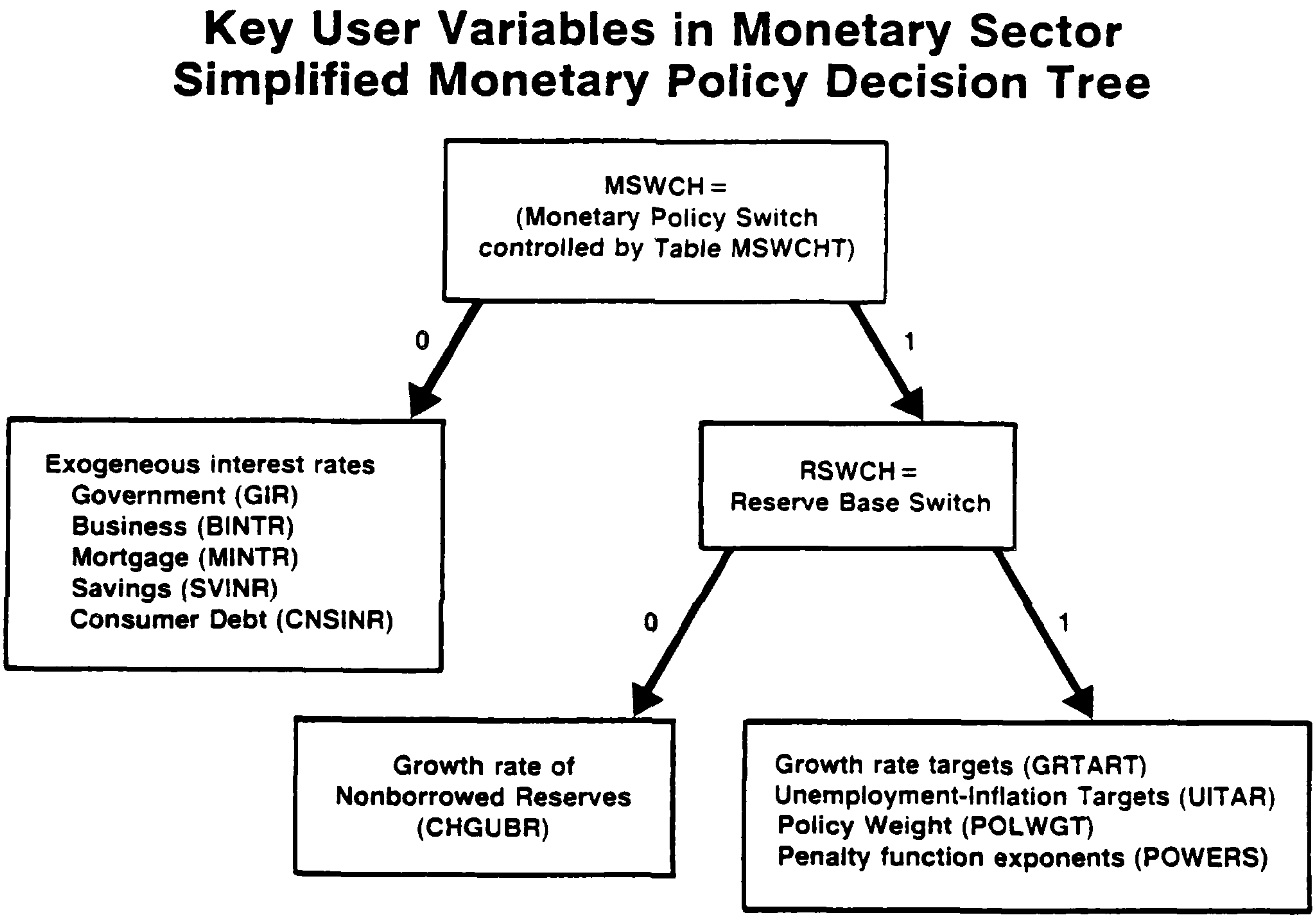

FIGURE B.2 Monetary Policy Decision Logic

T   MSWCHT = i/j

i = 0,1 for normal economy

j = 0,1 for recovery economy

A setting of 1 enables the monetary policy sector as described above. The time length of the recovery economy is also specified by variable MPT which is analogous to variable GPIMPT discussed in section B.3. Thus, if we wished to impose exogenous interest rates for the first five post-attack years, then the appropriate change would be:

T   MSWCHT = 1/0

C   MPT = 5

Exogenous Interest Rates

If the value of MSWCH is 0 during a simulation, then interest rates are taken directly from user specified tables. Each table contains thirty values corresponding to years 1971 to 2000. Table values are for mid-years, thus the first value is for time period 1971.5. With this specification, values for the historical period can be approximated by annual average rates (the first thirteen values would be from 1971 through 1983). All interest rates are expressed as fractions. Five tables are used to specify the various interest rates in the model:

T   GIRITT=... (Government interest rate - 3 mo. bill rate)

T   BINYT=... (Business interest rate)

T   MINIRT=... (Mortgage interest rate)

T   SVINTR=... (Time deposit savings rate)

T   CNSINT=... (Consumer credit interest rate)

Exogenous Reserve Base Growth

Setting the constant RSWCH equal to zero allows the growth rate of unborrowed reserves (variable RBASE) to be specified by the user. The growth rates are determined by four-year intervals over the period 1972 to 2012 on table CHGUBR. As with any DYNAMO table function, the values are interpolated for periods between those specified on the table function card. As an example, consider the following two entries:

C   RSWCH = 0

T   CHGUBR = .10/.10/.10/.08/.08/.08/.08/.08/.08/

Since RSWCH is zero, unborrowed reserves will grow at 10 percent per year between 1972 and 1980, decelerate to 8 percent growth by 1984, and grow at constant 8 percent for all years thereafter.

Reactive Monetary Policy

Setting the MSWCH and RSWCH both equal to one prompts the monetary policy to be reactive, in the sense that the growth in the reserve base is determined by previous values of the overall growth rate of the economy, the unemployment rate, and the inflation rate. To reduce the number of separate variable names, parameters applicable to the normal and "recovery" situations are put into the same table.

The growth rate target is specified in table GRTART. Thus, for example, target growth rates of 2.5 percent per year during the pre-attack period and 5 percent during recovery, would be specified as:

T GRTART = .025/.05

The effect of deviations of unemployment and inflation rates from their target values is collapsed into a single value (as discussed in Section 3.3) as follows:

$$UIPOL = WGT_1 * (U/U*)^{POWR_1} + WGT_2 * (INFR/INFR*)^{POWR_2}$$

where

WGT_1, WGT_2 represent penalty weights ($WGT_2 + WGT_2 = 1$) on deviation from unemployment and inflation targets, respectively

U* = unemployment target (fraction)

INFR* = inflation target (fraction)

$POWR^1$ = power associated with deviation from unemployment target

$POWR^2$ = power associated with deviation from inflation target.

Three tables specify the targets and parameters that make up the above equation and are shown graphically in Table B.2. To illustrate how we might change these table functions, consider the following example. Assume that: 1) unemployment target normally is 6 percent and would be lowered to 4 percentduring recovery, 2) the inflation rate target is normally 5 percent but that 15 percent might be tolerated during recovery, and 3) the penalty function in both periods is linear for unemployment and is quadratic for inflation and

TABLE B.2. Organization of Unemployment-Inflation Policy Function Parameters

	Normal Period		Recovery Period
T UITAR =	U*/INFR*	/	U*/INFR*
T POLWGT =	WGT_1/WGT_2	/	WGT_1/WGT_2
T POWERS =	$POWR_1/POWR_2$	/	$POWR_1/POWR_2$

4) the relative weights on deviations from targets shifted from .5 and .5 to .6 (on U) and .4 (on INFR). These assumptions would be represented as:

```
T   UITAR = .06/.05/.04/.15
T   POWERS = 1/2/1/2
T   POLWGT = .5/.5/.6/.4
```

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EMW-C-0909, W.U. 4342-D

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